Vol. XXVIII, Part IV

DECEMBER, 1958

COMMONWEALTH INST. ENTOMOLOGY LIBRARY
1 OCT 1959
SERIAL
SEPARATE
Ab.60B

E & A

Indian Journal of AGRICULTURAL SCIENCE

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DLEHI

1959 (see back of cover)

Vol. XXVIII, Part IV December, 1958

THE INDIAN JOURNAL OF AGRICULTURAL SCIENCE

Issued under the authority

of

The Indian Council of Agricultural Research

Annual subscription
Rs. 10 or 16 sh.

Price per part
Rs. 2·50 nP. or 4 sh.

©

ICAR. 5. XXVIII, 4
2,300.

Digitized by the Internet Archive
in 2025

https://archive.org/details/indian-journal-of-agricultural-sciences_1958-12_28_part-4

CONTENTS

Vol. XXVIII, Part IV

(December, 1958)

The Publications Committee of the Indian Council of Agricultural Research, India, takes no responsibility for the opinion expressed in this Journal.

PAGE

Original Articles

POTASSIUM STATUS OF SOILS OF WESTERN INDIA. IV—EFFECT OF DIFFERENT LEVELS OF POTASSIUM IN *Goradu* SOIL ON THE UPTAKE OF CATIONS BY *bajri* (*Pennisetum typhoideum*) — *B. V. Mehta and C. C. Shah* — 473

DEVELOPMENT AND MORPHOLOGY OF VINDHYAN SOILS. II—NATURE OF EXCHANGEABLE BASES IN THE SOIL SEQUENCE OF THE UPPER VINDHYAN PLATEAU IN U. P. — *R. N. Gupta* — 491

DEVELOPMENT STUDIES ON CROP PLANTS. III—INVESTIGATIONS ON CHARACTER DIFFERENCES INDUCED BY FERTILIZATION IN RELATION TO LODGING SUSCEPTIBILITY IN WHEAT CROP — *P. C. Raheja and K. P. Misra* — 499

EFFECT OF TILLAGE AND SOURCE OF NITROGEN ON THE YIELD OF WHEAT — *B. D. Ganguly and L. L. Relwani* — 511

CHEMICAL COMPOSITION OF CIGAR TOBACCO LEAF AS INFLUENCED BY ITS POSITION ON THE STALK (WITH 2 TEXT-FIGURES) — *K. G. Tejwani, C. K. Ramakrishna Kurup, and K. V. Venkataraman.* — 519

PESTS OF CASHEW (*Anacardium occidentale*) IN SOUTH INDIA (WITH 4 TEXT-FIGURES) — *E. V. Abraham* — 531

THE BIOLOGICAL CONTROL OF COCCID PEST IN SOUTH INDIA BY THE USE OF THE BEETLE, *Cryptolaemus montrouzieri* MULS. (WITH 6 TEXT-FIGURES) — *V. Tirumala Rao and A. Leela David.* — 545

		PAGE
OBSERVATIONS ON THE TERMITES AFFECTING TEA IN NORTH-EAST INDIA AND THEIR CONTROL	*G. M. Das*	553
GLYPHODES BIVITRALIS GUEN., AS A NEW PEST OF JAK	*K. R. Nagaraja Rao and T. R. Subramaniam.*	561
EFFECT OF TOMATO VIRUS ON INFECTION OF BEAN PLANTS BY TOBACCO MOSAIC VIRUS	*B. B. Nagaich*	563
A NOTE ON THE OCCURRENCE OF LITTLE LEAF IN CLOVE (WITH 1 TEXT-FIGURE)	*M. A. Balasubramaniam*	567
TERPENYL ANALOGUES OF PARATHION (AS INSECTICIDES). TERPENE SERIES (III)	*V. V. Bhatia, R. S. Dewan, A. R. S. Kartha and K. C. Gulati.*	569
STUDIES ON THE VEGETATIVE PROPAGATION OF CASHEW (*ANACARDIUM OCCIDENTALE* LINN.). IV—THE NURSE-GRAFTED Y-CUTTING METHOD (WITH 1 TEXT-FIGURE)	*V. N. Madhava Rao and I. K. Sambashiva Rao.*	575
ACCUMULATION AND MOVEMENT OF MINERALS IN 'BAJRI' (*PENNISETUM TYPHOIDEUM*)	*B. V. Mehta and C. C. Shah*	583
A STUDY ON FODDERS OF HISSAR DISTRICT IN THE PUNJAB	*B. M. Patel, B. G. Shah and V. V. Mistry.*	597
DEFICIENCY SYMPTOMS IN SESAMUM INDICUM L. (GINGILI)—SYMPTOMS PRODUCED BY DEFICIENCY OF NITROGEN PHOSPHORUS, POTASSIUM, CALCIUM AND MAGNESIUM	*N. L. Pal and M. Bangarayya*	607
SOME PROBLEMS OF MARKETING OF CASH CROPS IN KOLHAPUR DISTRICT	*S. S. Madalgi*	613

Revewes

ELEMENTARY SOIL AND WATER ENGINEERING 623

Gossypium LINN.

GRASSLAND SEEDS

THE GRASSLAND AND FODDER RESOURCES OF INDIA

POTASSIUM STATUS OF SOILS OF WESTERN INDIA

IV. EFFECT OF DIFFERENT LEVELS OF POTASSIUM IN *GORADU* SOIL ON THE UPTAKE OF CATIONS BY 'BAJRI' (*PENNISETUM TYPHOIDEUM*)

By B. V. Mehta and C. C. Shah, Institute of Agriculture, Anand (Bombay)

[Received for publication on March 2, 1955
Accepted for publication on November 11, 1957]

PLANTS have become adjusted to their environments through a long process of evolution. The result is a tendency to require a definite concentration and balance of the various elements in the plant. In spite of this tendency, plant composition is found to vary to a certain extent in relation with the nutrient levels of soils. It is natural to expect that the three important cations, K^+, Ca^{++}, Mg^{++}, which compose the largest portion of the essential nutrient elements found in plant ash, would show a variation. Each of these cations performs certain well-known and specific roles. Any factor which interferes with these functions means a reduction in quality and quantity of plant growth. In spite of these essential functions attributed to each of these cations, there are many physiological functions, such as buffering of the cell-sap, neutralisation of organic acids and regulation of salt concentration, which are performed in common by any of the three cations. The interchangeability of the cations in performing these functions will have no effect on the quality and quantity of the crop. Any extreme deviation from a theoretical balance is not desirable, because many of the specific properties and functions of the cations are not interchangeable [Lucas and Scarseth 1947]. The present work was undertaken to examine as to what extent a variation in exchangeable potassium content of soil affects the uptake of the three important cations in the *bajri* plant and the inter-relationship between them.

Material and Methods

Bajri was grown in plots of *goradu* soil having a variation of 0·300 to 0·798 m.e. exchangeable potassium per 100 gm. There were four sets of treatments : (1 and 2) different doses of nitrogen were applied in the form of ammonium sulphate (Table I) and groundnut cake (Table II), (3) no fertilizer was given, but tobacco was grown during previous three years with different doses of groundnut cake and farmyard manure (Table III) and (4) no fertilizer treatment was given, but the plots were either ploughed to a depth of 14 inches with a tractor or to a depth of 5 inches by a country plough according to the indigenous method (Table IV).

TABLE I

Cation content of bajri *grown in* goradu *soil as affected by different levels of exchangeable potassium and nitrogen treatments in the form of ammonium sulphate*

Exch. K. m.e./100 gm.	Treatment lb. N. per acre	Grain				Ca+Mg. / K.
		Cation content m.e. per 100 gm. oven-dry weight				
		K	Ca.	Mg.	Total	
0·453	0	12·1	3·0	5·1	20·2	0·67
0·358	0	11·4	2·1	6·5	20·0	0·75
0·423	25	12·3	3·5	6·6	22·4	0·82
0·468	25	12·9	2·6	7·2	22·7	0·76
0·738	50	10·5	4·1	5·6	20·2	0·76
0·473	50	13·1	1·8	6·7	21·6	0·65
0·333	75	11·7	4·0	6·4	22·1	0·89
0·448	75	12·1	2·2	6·0	20·3	0·68
0·393	100	10·8	3·2	5·9	19·9	0·84
0·423	100	11·6	2·7	6·8	21·1	0·82
0·798	125	12·9	4·1	6·0	23·0	0·78
0·433	125	11·5	3·9	6·0	21·4	0·86
Mean		11·91	3·10	6·23	21·24	
S.D.		0·8196	0·8280	0·5776	1·1023	
C.V.		6·88	26·71	9·27	5·19	

TABLE I—contd.

Cation content of bajri *grown in* goradu *soil as affected by different levels of exchangeable potassium and nitrogen treatments in the form of ammonium sulphate*

Exch. K. m.e./100 gm.	Treatment lb. N. per acre	Empty earhead				
		Cation content m.e. per 100 gm. oven-dry weight				$\frac{Ca+Mg.}{K.}$
		K	Ca.	Mg.	Total	
0·453	0	40·0	10·0	3·6	55·6	0·39
0·358	0	41·2	9·0	6·0	56·2	1·36
0·423	25	38·0	12·0	6·0	56·0	0·47
0·468	25	37·1	7·5	5·8	50·4	0·36
0·738	50	41·5	6·6	5·5	53·6	0·30
0·473	50	37·6	11·0	7·4	56·0	0·49
0·333	75	37·1	10·0	4·7	51·8	0·39
0·448	75	36·7	8·6	4·5	49·8	0·35
0·393	100	33·6	10·0	6·3	49·9	0·49
0·423	100	41·0	9·2	5·2	55·4	0·35
0·798	125	36·2	9·0	6·4	51·6	0·43
0·433	125	35·3	9·5	5·6	50·4	0·43
Mean		37·94	9·37	5·75	53·06	
S.D.		2·5012	1·4041	0·7775	2·6503	
C.V.		6·59	14·99	3·52	4·99	

TABLE I—concld.

Cation content of bajri *grown in* goradu *soil as affected by different levels of exchangeable potassium and nitrogen treatments in the form of ammonium sulphate*

Exch. K. m.e./100 gm.	Treatment lb. N. per acre	Stalk with leaves				Ca+Mg. / K.
		Cation content m.e. per 100 gm. oven-dry weight				
		K	Ca.	Mg.	Total	
0·453	0	43·0	19·5	17·3	79·8	0·87
0·358	0	39·8	19·6	14·3	73·7	0·82
0·423	25	42·5	21·5	17·3	81·3	0·91
0·468	25	46·3	16·7	10·0	73·0	0·58
0·738	50	58·5	14·0	10·0	82·5	0·42
0·473	50	47·7	12·8	10·6	71·1	0·49
0·333	75	43·8	14·1	13·0	70·9	0·62
0·448	75	45·3	20·0	12·0	77·7	0·71
0·393	100	48·7	16·1	15·9	80·7	0·66
0·423	100	40·0	16·8	15·8	72·6	0·81
0·798	125	65·9	29·0	13·2	108·1	0·64
0·433	125	46·8	15·5	12·3	74·6	0·62
Mean		47·36	17·97	13·48	78·83	
S.D.		7·6400	4·3034	2·6442	10·0980	
C.V.		16·13	23·92	19·62	12·81	

TABLE II

Cation content of bajri *grown in* goradu *soil as affected by different levels of exchangeable potassium and nitrogen treatment in the form of groundnut cake*

Exch. K. m.e./100 gm.	Treatment lb. N. per acre	Grain				$\frac{Ca+Mg.}{K.}$
		Cation content m.e. per 100 gm. oven-dry weight				
		K	Ca.	Mg.	Total	
0·333	0	12·3	2·1	6·3	20·7	0·68
0·348	0	12·8	2·3	6·9	22·0	0·72
0·338	20	13·0	2·3	5·0	20·3	0·56
0·348	20	13·4	1·8	6·4	21·6	0·61
0·330	30	13·4	1·9	6·0	21·2	0·60
0·298	30	13·0	2·1	6·6	21·7	0·67
0·338	40	11·7	1·9	6·6	20·2	0·73
0·300	40	12·9	1·7	6·0	20·6	0·60
0·330	50	12·8	2·0	6·4	21·2	0·66
0·310	50	12·7	2·3	6·8	21·8	0·71
Mean		12·80	2·04	6·30	21·14	
S.D.		0·5033	0·2161	0·5457	0·6498	
C.V.		3·93	10·59	8·66	3·07	

TABLE II—contd.

Cation content of bajri *grown in* goradu *soil as affected by different levels of exchangeable potassium and nitrogen treatment in the form of groundnut cake*

Exch. K. m.e./100 gm.	Treatment lb. N. per acre	Earhead without grain				
		Cation content m.e. per 100 gm. oven-dry weight				$\frac{Ca+Mg.}{K.}$
		K	Ca.	Mg.	Total	
0·333	0	32·2	7·6	6·4	46·2	0·44
0·348	0	33·6	10·4	5·9	49·9	0·49
0·338	20	35·3	8·6	6·1	50·0	0·42
0·348	20	30·9	9·6	6·4	46·9	0·52
0·330	30	33·7	8·2	6·0	47·9	0·42
0·298	30	31·8	9·0	6·4	47·2	0·49
0·338	40	38·5	8·2	6·4	53·1	0·38
0·300	40	35·0	8·6	5·6	49·2	0·41
0·330	50	31·4	9·2	5·8	46·4	0·48
0·310	50	32·7	8·0	5·3	46·0	0·41
Mean		33·51	8·74	6·03	48·28	
S.D.		2·2083	0·8326	0·3859	2·2059	
C.V.		6·59	9·53	6·40	4·57	

TABLE II—concld.

Cation content of bajri *grown in* goradu *soil as affected by different levels of exchangeable potassium and nitrogen treatment in the form of groundnut cake*

Exch. K. m.e./100 gm.	Treatment lb. N. per acre	Stalk with leaves				$\frac{Ca.+Mg.}{K.}$
		Cation content m.e. per 100 gm. oven-dry weight				
		K	Ca.	Mg.	Total	
0·333	0	44·5	26·3	11·0	81·8	0·84
0·348	0	43·0	14·5	13·6	71·1	0·66
0·338	20	39·0	28·5	14·0	81·5	1·11
0·348	20	43·5	14·2	14·3	72·0	0·66
0·330	30	48·0	16·6	14·8	79·4	0·66
0·298	30	40·5	14·8	15·9	71·2	0·73
0·338	40	45·6	14·5	15·2	75·3	0·65
0·300	40	35·2	24·8	15·4	75·4	1·14
0·330	50	46·0	15·1	16·8	77·9	0·69
0·310	50	40·3	20·8	17·0	78·1	0·94
Mean		42·56	19·01	14·80	76·37	
S.D.		3·8249	5·5030	1·7043	4·0374	
C.V.		8·99	28·95	11·52	5·27	

Table III

Cation content of bajri *grown in* goradu *soil as affected by different levels of exchangeable potassium and residual manure of tobacco plots treated with farmyard manure and groundnut cake*

Exch. K.m.e./ 100 gm.	Treatment of previous tobacco crop (per acre)	Grain				Ca+Mg / K.
		Cation content m.e. per 100 gm. oven-dry weight				
		K	Ca.	Mg.	Total	
0·498	*Nil*	10·9	4·3	6·9	22·1	1·03
0·463	*Nil*	9·3	3·5	7·2	20·0	1·15
0·763	5 tons F.Y.M.	10·3	3·2	6·8	20·3	0·97
0·615	5 tons F.Y.M.	11·4	3·3	6·8	21·5	0·89
0·565	2½ tons F.Y.M. + 25 lb. N. as cake	11·1	2·5	6·8	20·4	0·84
0·448	2½ tons F.Y.M. + 25 lb. N. as cake	10·7	3·5	6·4	20·6	0·92
0·650	5 tons F.Y.M. + 25 lb. N. as cake	10·6	4·0	7·0	21·6	1·04
0·660	5 tons F.Y.M. + 25 lb. N. as cake	10·9	3·3	6·7	20·9	0·92
0·688	5 tons F.Y.M. + 50 lb. N. as cake	12·0	4·0	6·4	22·4	0·87
0·723	5 tons F.Y.M. + 50 lb. N. as cake	12·0	4·3	6·4	22·7	0·89
0·788	7½ tons F.Y.M. + 25 lb. N. as cake	12·3	3·3	6·8	22·4	0·82
0·718	7½ tons F.Y.M. + 25 lb. N. as cake	10·7	3·8	5·8	20·3	0·89
0·783	7½ tons F.Y.M. + 50 lb. N. as cake	12·0	3·5	5·2	20·7	0·73
0·736	7½ tons F.Y.M. + 50 lb. N. as cake	11·1	3·8	5·8	20·7	0·87
0·423	50 lb. N. as cake	11·3	4·0	6·6	21·9	0·94
0·413	50 lb. N. as cake	11·4	3·3	6·1	20·7	0·82
	Mean	11·13	3·60	6·48	21·21	
	S. D.	0·7576	0·4690	0·5266	0·8752	
	C. V.	6·81	13·03	8·13	4·13	

TABLE III—contd.

Cation content of bajri *grown in* goradu *soil as affected by diff rent levels of exchangeable potassium and residual manure of tobacco treated with farmyard manure and groundnut cake*

Exch. K. m.e./ 100 gm.	Treatment of previous tobacco crop (per acre)	Earhead without grain				
		Cation content m.e. per 100 gm. oven-dry weight				$\frac{Ca+Mg}{K}$
		K	Ca.	Mg.	Total	
0·498	Nil	22·1	16·0	8·1	46·2	1·09
0·463		26·0	12·0	8·3	46·3	0·78
0·763	5 tons F.Y.M.	25·8	14·1	6·5	46·4	0·79
0·615		28·3	13·0	4·8	46·1	0·63
0·565	2½ tons F.Y.M.+25 lb. N. as cake	29·1	11·4	7·5	48·0	0·65
0·448		27·0	12·5	6·6	46·1	0·71
0·650	5 tons F.Y.M.+25 lb. N. as cake	23·5	14·8	8·1	46·4	1·02
0·660		24·8	14·1	8·0	46·9	0·89
0·688	5 tons F.Y.M.+50 lb. N. as cake	22·5	16·0	8·0	46·5	1·07
0·723		26·6	12·0	7·5	46·1	0·74
0·788	7½ tons F.Y.M.+25 lb. N. as cake	28·5	12·5	6·7	47·7	0·68
0·718		23·9	16·0	6·4	46·3	0·93
0·783	7½ tons F.Y.M.+50 lb. N. as cake	30·1	10·2	5·9	46·2	0·53
0·730		27·5	12·0	8·2	47·7	0·74
0·423	50 lb. N. as cake	29·4	11·0	5·5	45·9	0·56
0·413		26·0	12·0	7·9	45·9	0·77
	Mean	26·32	13·1	7·13	46·54	
	S. D.	2·4064	1·8051	1·0088	0·6603	
	C.V.	9·14	13·78	14·15	1·42	

TABLE III—contd.

Cation content of bajri *grown in* goradu *soil as affected by different levels of exchangeable potassium and residual manure of tobacco treated with farmyard manure and groundnut cake*

Exch. K.m.e./ 100 gm.	Treatment of previous tobacco crop (per acre)	Stalk with leaves				
		Cation content m.e. per 100 gm. oven-dry weight				$\frac{Ca+Mg}{K}$
		K	Ca.	Mg.	Total	
0·498	*Nil*	45·0	14·4	12·2	71·6	0·59
0·463	*Nil*	45·1	14·5	11·1	70·7	0·57
0·763	5 tons F.Y.M.	38·4	21·6	14·2	74·2	0·91
0·615	5 tons F.Y.M.	43·2	16·1	12·3	71·6	0·66
0·565	2½ tons F.Y.M.+25 lb. N. as cake	45·1	17·9	8·6	71·6	0·54
0·448	2½ tons F.Y.M.+25 lb. N. as cake	42·6	22·2	12·4	77·2	0·81
0·650	5 tons F.Y.M.+25 lb. N. as cake	30·3	27·0	14·1	71·4	1·36
0·660	5 tons F.Y.M.+25 lb. N. as cake	33·0	26·0	12·1	71·1	1·16
0·688	5 tons F.Y.M.+50 lb. N. as cake	47·0	17·1	12·0	76·1	0·62
0·723	5 tons F.Y.M.+50 lb. N. as cake	45·0	16·1	11·6	72·7	0·62
0·788	7½ tons F.Y.M.+25 lb. N. as cake	35·6	23·2	14·3	73·1	1·06
0·718	7½ tons F.Y.M.+25 lb. N. as cake	31·8	28·6	13·6	74·0	1·33
0·783	7½ tons F.Y.M.+50 lb. N. as cake	42·4	19·0	14·3	75·7	2·78
0·750	7½ tons F.Y.M.+50 lb. N. as cake	38·1	21·2	12·4	71·7	0·88
0·423	50 lb. N. as cake	44·3	16·0	11·4	71·7	0·62
0·413	50 lb. N. as cake	36·4	28·7	16·5	81·6	1·24
	Mean	40·23	20·60	12·69	73·50	
	S. D.	5·2678	4·9649	1·7094	2·9184	
	C. V.	13·09	24·10	13·47	3·97	

TABLE IV

Cation content of bajri *grown in unmanured* goradu *soil as affected by deep and shallow ploughing*

Exch. K, m.e./ 100 gm.	Treatment	Grain				
		Cation content m.e. per 100 gm. oven-dry weight				$\frac{Ca+Mg}{K}$
		K	Ca.	Mg.	Total	
0·370	Deep ploughing	14·0	2·0	5·0	21·0	0·50
0·380	Shallow ploughing	13·3	1·9	6·0	21·2	0·60
0·370	Deep ploughing	14·1	2·0	6·0	22·1	0·57
0·350	Shallow ploughing	13·3	2·0	6·1	21·4	0·61
0·330	Deep ploughing	12·9	2·2	5·9	21·0	0·62
0·380	Shallow ploughing	13·2	1·9	5·9	21·0	0·59
0·350	Deep ploughing	12·9	1·9	5·9	20·7	0·60
0·325	Shallow ploughing	13·1	2·1	6·0	21·2	0·62
0·345	Deep ploughing	12·9	1·8	6·0	20·7	0·60
	Mean	13·30	1·98	5·87	21·14	
	S. D.	0·4555	0·1225	0·3317	0·4243	
	C. V.	3·42	6·19	5·65	2·01	

TABLE IV— contd.

Cation content of bajri *grown in unmanured* goradu *soil as affected by deep and shallow ploughing*

Exch. K. m.e./ 100 gm.	Treatment	Earhead without grain				
		Cation content m.e. per 100 gm. oven-dry weight				$\frac{Ca+Mg}{K}$
		K	Ca.	Mg.	Total	
0·370	Deep ploughing	33·6	10·0	6·0	49·6	0·48
0·380	Shallow ploughing	29·8	10·4	5·8	46·0	0·55
0·370	Deep ploughing	32·0	10·0	4·7	46·7	0·46
0·350	Shallow ploughing	34·4	7·6	4·4	46·4	0·32
0·330	Deep ploughing	35·0	8·0	4·7	47·7	0·36
0·380	Shallow ploughing	38·0	8·0	4·5	50·5	0·33
0·350	Deep ploughing	36·4	8·4	4·3	49·1	0·35
0·325	Shallow ploughing	35·0	7·0	4·6	46·6	0·33
0·345	Deep ploughing	39·1	7·8	3·3	50·2	0·28
	Mean	34·81	8·58	4·70	48·09	
	S. D.	2·8681	2·2031	0·8031	1·7071	
	C. V.	8·24	14·02	17·09	3·55	

TABLE IV—concld.

Cation content of bajri *grown in unmanured* goradu *soil as affected by deep and shallow ploughing*

Exch. K. m.e./ 100 gm.	Treatment	Stalk with leaves				
		Cation content m.e. per 100 gm. oven-dry weight.				$\frac{Ca+Mg}{K}$
		K	Ca.	Mg.	Total	
0·370	Deep ploughing	41·3	21·9	18·5	81·7	0·98
0·380	Shallow ploughing	47·5	18·8	16·0	82·3	0·75
0·370	Deep ploughing	30·0	23·8	19·5	73·3	1·44
0·350	Shallow ploughing	31·0	22·0	18·0	71·0	1·30
0·330	Deep ploughing	35·3	23·8	19·4	78·5	1·22
0·380	Shallow ploughing	43·5	20·3	15·3	79·1	0·82
0·350	Deep ploughing	49·8	20·0	12·2	82·0	0·65
0·325	Shallow ploughing	40·3	22·8	15·3	78·4	0·95
0·345	Deep ploughing	40·5	23·8	16·8	81·1	1·00
	Mean	39·91	21·91	16·78	78·60	
	S. D.	6·7970	1·8052	2·3063	3·9887	
	C. V.	17·03	8·24	13·74	5·07	

The aerial parts of the plant were separated into grain, empty earhead and stalk with leaves. They were analysed for potassium by the usual volumetric procedure, for calcium by the A.O.A.C. [1945] volumetric method and for magnesium by volumetric method of Hardin and McIntire [1949]. As the role of calcium, magnesium and potassium within the plant is dependent upon their presence in the ionically active form, it is apparent that a consideration of content in terms of equivalents would present a better picture of the relative reactivity of these elements than their percentage by weight. The results of analysis have hence been given in terms of milliequivalents per 100 gm. The standard deviations and coefficients of variability have also been calculated for potassium, calcium, magnesium and total cation contents of different plant parts for easy comparisons.

Results and Discussion

Results given in Tables I, II, III and IV show that potassium forms a major part of the three important cations in all the parts of the *bajri* plant, amounting to more than 50 per cent in many cases and 70 in some. The cations are concentrated in the stalks and leaves. The grain contains the minimum amount of the cations.

While the exchangeable potassium of the soil varies from 0·300 to 0·798 m.e. per 100 gm., the potassium content of the grain changes only from 9 to 14 m.e. per 100 gm., that of the earhead from 22 to 42 m.e. and that of the stalk with leaves from 30 to 66 m.e. A wider variation is observed in the potassium content of the stalk than in either the grain or empty earhead. Minimum variation is observed in the grain. Association between the potassium percentages of the different plant parts and of the exchangeable potassium content of the soil is not seen except in a few cases. At higher levels of exchangeable potassium, there is a tendency for heavy consumption of potassium by the plant in the case of ammonium sulphate plots (65·9 m.e. per 100 gm. of stalks and leaves on soil with exchangeable potassium 0·798 m.e. per 100 gm.), while in the case of tobacco residual plots with almost equal exchangeable potassium (0·788 m.e.), the consumption of potassium by the plant is a little more than half, being 35·6 m.e. only for stalks and leaves. In the groundnut-treated plots, wherein the fluctuation in exchangeable potassium is not as wide as in the case of ammonium-sulphate-treated plots, the differences in cation contents are not wide. In unmanured plots, which are either deep or shallow ploughed only and which have a low exchangeable potassium level (0·325 to 0·380 m.e.) the potassium and also the total cation content of the plant parts is not lower than in tobacco residual plots with higher exchangeable potassium (0·413 to 0·788 m.e.).

The calcium content varies from 2 to 4 m.e. per 100 gm. in the grain, from 7 to 16 m.e. in the empty earhead and 13 to 29 in the stalk with leaves. There is greater variability in the calcium content of any part of the *bajri* plant than the potassium or magnesium content as is shown by the coefficients of variability, only exception being the magnesium content of the empty earhead and stalk and the

potassium content of the stalk in deep and shallow ploughed plots. There does not appear to be any direct relationship bewteen the calcium content and the amount of exchangeable potassium in the soil.

The content of magnesium varies from 5 to 7 m.e. in the grain, from 3 to 8 m.e. in the empty earhead and from 9 to 20 m.e. in the stalk with leaves. Greater variability is observed in the magnesium content of *bajri* plant parts than the potassium content, only exception being the potassium content of stalk in deep and shallow ploughed plots. The total cation content of the grain is nearly constant being 20 to 23 m.e. per 100 gm. Differences in potassium concentration are compensated by reciprocal differences in the concentrations of calcium and magnesium, thus making a nearly constant total cation concentration. Though the exchangeable potassium level of the soil varies by more than 100 per cent, a constant content of total cations is maintained in the *bajri* grain.

The total cation content of the empty earhead is more than double that of the grain in most cases. While potassium in the empty earhead varies from 22 to 42 m.e. per 100 gm., the total cation content varies from 46 to 56 m.e. In the empty earhead also there is tendency of reciprocal adjustment among the basic cations, but it is not complete.

The total cation content of the stalk with leaves is the highest. While the potassium content of the stalk with leaves varies from 30 to 66 m.e., the total cation content varies only from 71 to 82 m.e. per 100 gm. (In the case where the exchangeable potassium is very high, viz. 0·798 per 100 gm. soil, the total cation content is abnormally high, viz. 108). Leaving aside this exceptional case, the constancy of total cations is nearly maintained in these tissues as well.

In general, it may be said that differences in potassium content of different aerial parts of *bajri* plant arising out of differences in potassium level of *goradu* soil or fertilizer treatment are compensated by reciprocal differences in calcium and magnesium. This is substantiated by the figures of coefficients of variability for total cation content, which are less than the coefficients of variability of potassium, calcium or magnesium in any of the plant parts. Such an observation has also been recorded by McCalla and Woodford [1938] who found that in wheat limiting the supply of one nutrient resulted in an increased uptake of another nutrient absorbed as an ion of the same sign. Hoagland [1931] reported that in numerous water culture experiments decreasing the percentage of potassium in plant tissues was accompanied by an increase in the percentages of calcium and magnesium. In many cases an exact substitution of bases was observed but in some cases the total base absorption by the plant was greater under high potassium conditions than under low. Van Itallie [1938] working on Itallian rye grass, Lucas *et al.* [1942] working on alsike, alfalfa, red clover and soya-bean straw, Bear and Prince [1945] working on alfalfa, Naftel [1937] as reported by Lucas *et al.* (*loc. cit.*) working on sorghum and Marshall [1944] working on four pasture species have observed that cation substitution or mutual replacement took place and the total concentration of cations in the plant remained nearly constant, notwithstanding extreme deviations

in the concentrations of individual cations. But not all, investigators have observed cation constancy [Albrecht and Schroeder, 1942 ; Boynton and Burrell, 1944 ; Mehlich and Reed, 1946 ; Stanford *et al.*, 1942]. Stanford *et al.* on the other hand place emphasis on $\frac{Ca+Mg}{K}$ ratio. They have shown that for the corn plant deficient in potassium, this ratio is 6·1 whereas for normal plants it is 3·6. They have suggested that $\frac{Ca+Mg}{K}$ for the corn plant of less than 3·6 indicates an adequate level of nutrition. In the present study the ratio $\frac{Ca+Mg}{K}$ in the case of grain varies from 0·56 to 1·15 ; in the case of earhead without grain from 0·30 to 1·09 and in the case of stalks with leaves from 0·42 to 1·44 and no potassium deficiency symptoms have been observed in the *bajri* plant under any fertilizer treatment or at any level of exchangeable potassium. From these data, it is safe to say that if the ratio $\frac{Ca+Mg}{K}$ is less than 1·5 in grain, empty earhead or straw of the *bajri* plant at the harvest stage, it can be considered that the crop does not suffer from lack of potassium.

Summary

1. Potassium is the dominant cation in the *bajri* plant. A wider variation is observed in potassium, calcium and magnesium contents of the stalk with leaves than in the grain and empty earhead of the *bajri* plant grown in *goradu* soil with varying exchangeable potassium contents and under different fertilizer treatments. Minimum variation is observed in the grain. The total cation percentage of the stalk with leaves is higher than that of the other tissues.

2. In spite of the individual variations in potassium contents of the different parts of the *bajri* plant, the sum of these cations is almost constant. The differences in potassium content are compensated by reciprocal differences in calcium and magnesium.

3. The ratio $\frac{Ca+Mg}{K}$ in the case of *bajri* plant, grown on soil at different levels of exchangeable potassium and fertilizer treatments, varies from 0·56 to 1·15 for the grain, 0·30 to 1·09 for the empty earhead and 0·42 to 1·44 for the stalk with leaves. It is safe to say that if the ratio is less than 1·5 in grain, empty earhead or strain of *bajri* plant at harvest stage, it can be considered that the crop does not suffer from lack of potassium.

Acknowledgement

The authors express their thanks to Dr. M. D. Patel, Director, Institute of Agriculture, Anand, for his kind help and encouragement and Prof. P. L. Patel, Head of the Division of Plant Breeding and Agronomy for valuable advice and providing samples from the plots under his charge.

REFERENCES

Albrecht, W. A. and Schroeder, R. A. (1942). *Soil. Sci.* **53**, 313-327
Association of Official Agricultural Chemists (1945) ; *Official and Tentative methods* 6th Ed.
Bear, F. E. and Prince, A. J. (1945). *J. Amer. Soc. Agron.* **37**, 217-222
Boynton, D. and Burrell, A. B. (1944). *Soil Sci.* **58**, 441-454
Hardin, L. J. and MacIntire, W. H. (1949). *J. A. O. A. C.* **32**, 139
Hoagland, D. R. (1931). *Deuxieme Congress International de Pathologie Comparee* **2**, 402-404
Lucas, R. E., Scarseth, G. D. and Sieling, D. H. (1942). *Purdue Uni. Agri. Exp. Sta. Bull.* 468
————(1947). *J. Amer. Soc. Agron.* **39**, 887-896
Marshall, C. E. (1944). *Miss. Agri. Exp. Sta. Res. Bull.* 385
Mc. Calla, A. G. and Woodford, E. K. (1938). *Plant Physiol.* **13**, 695-712
Mehlich, A. and Reed, J. F. (1946). *Soil Sci. Soc. Amer. Proc.* **10**, 87-93
Naftel, J. A. (1937). *ibid.* **29**, 537-547
Stanford, G., Kelley, J. B. and Pierre, W. H. (1942). *Soil Sci. Soc. Amer. Proc.* **6**, 335-341
Van Italie Th. B. (1938). *Soil Sci.* **46**, 175-186.

DEVELOPMENT AND MORPHOLOGY OF VINDHYAN SOILS

II—NATURE OF EXCHANGEABLE BASES IN THE SOIL SEQUENCE OF THE UPPER VINDHYAN PLATEAU IN U.P.

By R. N. Gupta, Regional Soil Laboratory, Varanasi (U. P.)

[Received for publication on January 29, 1957
Accepted for publication on September 9, 1957]

RUSSELL [1950] while discussing the influence of topography on soil formation observed that tropical and subtropical soil sequences differ from those in temperate regions in that the *p*H of the soil on the plateau decreases as the drainage becomes poorer in the warmer regions, but increases in the cooler regions. An instance has been quoted by Jenny [1941] from the work of Holmes, Hearn and Byers [1938] on the soil series of the southern Atlantic Coastal Plains of the United States, while Gethin Jones [1949] has reported a similar consequence of impeded drainage in Kikuyu Series of Kenya colony. In soils of the Vindhyan plateau, as reported in an earlier communication [Agarwal, Mehrotra and Gupta, 1957], the relationship between drainage and profile features was found to follow two extreme patterns across the catenary sequence in that in one direction the *p*H of the soil increases as one descends the plateau, while in another direction, the acidity increases depending upon whether the illuviated products of weathering, particularly the alkalies and alkaline earths get a chance to accumulate or leach out of the profile on submergence accompanied by slow percolation. Accordingly, the broad topographical sites, viz. Vindhyan uplands, Vindhyan flats and Vindhyan lowlands are individually associated with a spectrum of soil characteristics whose range of variation broadens with varying conditions of drainage impedence from uplands to lowlands. In the present article has been described a study to determine the composition and variation of exchangeable bases in the Vindhyan soil sequence and discuss their pedo-chemical aspects in relation to other properties which lead to such variation in soil characteristics, particularly soil reaction.

Material and Methods

The Vindhyan catena consisted of a rapidly drained sandy loam of the red earth-type with a shallow eluviated profile and underlained by iron concretions on the uplands, a fairly well-drained red loam having a deeper profile and a sluggishly drained loam of heavier texture on the flats and a moderately drained acid red clay and a poorly drained alkaline black clay with lime concretions on the lowlands. In the present study, the five types of Vindhyan soils reported in an earlier communication (*loc. cit.*) have been studied with respect to their exchangeable bases, cation exchange capacity and degree of base unsaturation. The data on base exchange are given in Table I together with their chief chemical characteristics.

TABLE I

Exchangeable bases, base exchange capacity and some chemical characteristics of Vindhyan soils

(Per cent oven-dry basis)

Horizon	Depth (in inches)	Exchangeable cations m.e.					Base exchange capacity m.e.
		Ca	Mg	K	Na	H	
A	0—6	3·03	0·81	0·14	0·26	0·61	4·85
B2	6—36	7·55	2·45	0·31	0·48	1·10	11·89
B3	36—48	7·98	2·45	0·35	0·51	0·28	11·57
A	0—5	5·31	2·04	0·29	0·20	1·83	9·67
B1	5—20	8·05	3·20	0·33	0·48	1·50	13·55
B2	20—32	9·61	5·23	0·52	0·52	0·84	16·72
	32—56	7·79	3·95	0·59	0·54	0·46	13·32
A	0—9	7·26	3·23	0·32	0·28	0·51	11·61
B1	9—21	7·87	2·93	0·36	0·35	1·11	12·62
B2	21—33	10·57	3·56	0·46	..	..	16·07
	33—49	11·62	4·18	0·46	0·82	0·92	18·00
	49—72	12·41	4·17	0·41	0·97	nil	17·09
	0—7	3·66	2·46	0·14	nil	4·51	10·76
B21	7—19	7·94	4·33	0·31	0·29	2·31	15·18
B22	19—48	8·42	4·96	0·30	0·31	2·03	16·02
	48—72	9·51	5·38	0·43	0·37	0·93	16·63
A	0—5	13·42	1·64	0·43	0·45	nil	15·70
Bca	5—25	13·02	4·55	0·40	0·96	nil	17·76
	25—41	5·58	7·85	0·31	2·81	nil	16·12
BCsa	41—72	3·30	7·21	0·47	5·49	nil	15,50

TABLE I—contd.

Exchangeable bases, base exchange capacity and some chemical characteristics of Vindhyan soils

(*Per cent oven-dry basis*)

Horizon	Depth (in inches)	Saturation percentage					Ex. Ca/Mg	pH
		Ca	Mg	K	Na	H		
		Vindhyan soil type 1 (upland)						
A	0—6	62·5	16·7	2·9	5·4	12·5	3·74	6·1
B2	6—36	63·5	20·6	2·6	4·0	9·3	3·07	6·0
B3	36—48	69·0	21·2	3·0	4·4	2·4	3·26	6·9
		Vindhyan soil type 2 (flatland)						
A	0—5	54·9	21·1	3·0	2·1	18·9	2·60	5·7
B1	5—20	59·4	23·6	2·4	3·5	11·1	2·52	6·0
B2	20—32	57·5	31·3	3·1	3·1	5·0	1·84	6·4
	32—56	58·5	29·7	4·4	4·1	3·5	1·97	6·6
		Vindhyan soil type 3 (flatland)						
A	0—9	62·5	27·8	2·8	2·4	4·4	2·25	6·4
B1	9—21	62·4	23·2	2·9	2·8	8·8	2·69	6·4
B2	21—33	65·8	22·2	2·9	..	..	2·97	6·6
	33—49	64·6	23·2	2·6	4·6	5·1	2·78	6·7
	49—72	72·6	24·4	2·4	5·7	nil	2·97	7·0
		Vindhyan soil type 4 (lowland)						
A	0—7	34·0	22·9	1·3	nil	41·8	1·49	4·9
B21	7—19	52·3	28·5	2·0	1·9	15·2	1·83	5·6
B22	19—48	52·6	31·0	1·9	1·9	12·7	1·70	5·8
	48—72	57·2	32·4	2·6	2·2	5·6	1·77	6·0
		Vindhyan soil type 5 (lowland)						
A	0—5	85·5	10·4	2·7	2·9	nil	8·18	7·5
Bca	5—25	73·3	25·6	2·3	5·4	nil	2·86	8·1
	25—41	34·6	48·7	1·9	17·4	nil	0·71	8·3
BCsa	41—72	21·3	46·5	3·0	35·4	nil	0·46	8·7

TABLE I—contd.

Exchangeable bases, base exchange capacity and some chemical characteristics of Vindhyan soils

(*Per cent oven-dry basis*)

Horizon	Depth (in inches)	Organic matter	Soil composition		Clay composition		
			Base* status*	CaO MgO	SiO_2 R_2O_3	Al_2O_3 Fe_2O_3	Base ex. cap.
			Molecular ratios		Molecular ratios		
A	0—6	0·93	0·463	1·02	1·95	4·13	27 me
B2	6—36	0·53	0·379	0·58	1·81	3·95	22
B3	36—48	0·76	0·335	0·56	1·78	3·98	24
A	0—5	1·74	0·378	0·80	2·11	4·24	32
B1	5—20						
B2	20—32	0·56	0·331	0·53	1·88	4·24	26
	32—56						
A	0—9	1·67	0·591	0·47	2·29	4·34	42
B1	9—21						
B2	21—33	0 31	0·506	0·44	2·19	4·33	36
	33—49						
	49—72						
A	0—7	1·46	0·352	0·34	2·10	5·74	34
B21	7—19						
B22	19—48	0·42	0·305	0·33	2·08	4·85	33
	48—72						
A	0—5	2·37	0·648	1·18	2·39	4·18	53
Bca	5—25						
	25—41	0·33	0·334	1·83	2·58	3·95	48
BCsa	41—72	0·24	0·506	0·90	2·37	4·34	44

* $CaO + MgO + K_2O/Al_2O_3$

Exchangeable bases were determined in samples prepared through 2 mm. sieve. Exchangeable Ca. and Mg. were determined by the Hissink's method [1923]. Exchangeable Na and K were determined in normal ammonium acetate leachate. Base exchange capacity was determined by washing the ammonium-acetate leached soil with neutral alcohol and distilling it with ignited magnesia. In case of acid soils, better replacement was effected through neutral barium-acetate leaching and exchange capacity was determined by estimating the absorbed barium on replacement with ammonium chloride [Parker, 1927]. Exchangeable H was found by difference.

Experimental Results and Discussion

In Table I the percentage saturation of the respective bases and the degree of base unsaturation have been calculated separately. From a perusal of the data, it may be observed that Vindhyan soil type is low in exchangeable bases. The exchange capacity and the individual exchangeable cations increase with depth. Expressed as percentage of the total metallic cations, Ca occupies about 70 per cent, Mg 22 per cent and the rest 5 to 6 per cent is occupied by Na and K. Base unsaturation amounts to only 12 per cent at the surface but decreases with depth.

Soil types 2 and 3 collected from Vindhyan flats possess higher exchange capacity than the upland soils. The individual exchangeable cations also increase in the same proportion. The trend of variation of the bases is, however, similar to type 1 soils except that type 2 soils are more acidic and hence more base unsaturated and, in addition, magnesium leaching is more evident in the profile. Magnesium saturation has increased about 10 per cent at the cost of calcium. Type 3 soils, on the other hand, developed under restricted drainage, are more base saturated than type 1 soils, and in contrast to type 2 soils, are better supplied with exchangeable calcium.

On coming to Vindhyan lowlands, the exchange capacity in soil types 4 and 5 again increases over types 2 and 3 respectively, particularly in upper horizons, but the contrast among themselves becomes more pronounced. Vindhyan soil type 4 which is fairly well-drained is highly acidic and the base unsaturation also increases to a maximum of 42 per cent at the surface. Calcium saturation has decreased while Mg saturation has increased. In marked contrast to these soils, Vindhyan type 5 is an alkaline calcimorphic soil fully base saturated. The upper horizons possess high calcium saturation but the subsoil shows some salinization effect and calcium has largely been replaced by Mg and Na.

Since the catena idea in essence is the dependence of soil types on drainage conditions, and the latter differs markedly both externally and internally on broad topographical sites of the plateau, as many as five profiles have been selected to illustrate the catenary relationship existing in the soil sequence of the Vindhyan plateau. Except for the uplands from which only one soil type has been selected, the profiles have been presented in pairs of red and gray soils, e.g. types 2 and 3 from flatlands and types 4 and 5 from Vindhyan lowlands, to represent only the extreme ends of

the drainage scale existing on the individual topographical sites. The bulk of the data presented on the exchangeable bases point out clearly what has been concluded from earlier studies that the spectrum of soil characteristics broadens greatly as one descends from uplands to lowlands on the plateau. On the uplands, differences among the soils are not significant, except for some depth phases, because of the rapid external and internal drainage, but on moving towards flats, foothills, and lowlands, the surface drainage gradually gives way to internal drainage which spread out from a fairly good to practically non-existent level. The differences in exchangeable bases and the soil reaction as a corollary assume prominence accordingly. Thus in soil types 1, 2 and 4, associated with rapid, good and moderately good to fair drainage respectively, the exchange acidity increases in that order and is in confirmity with their *p*H values. The percentage of Ca saturation decreases, whereas Mg saturation increases in the order of increasing acidity in the sequence. Leaching of the bases is evident in all the three profiles, but magnesium leaching is more prominent. This gradual replacement of Ca by Mg ions is noteworthy. Base unsaturation proceeds through the replacement of metallic cations by hydrogen ions whose absorbing energy is four times that of Ca ions. Since the exchangeable Mg, K and Na are more easily replaced than Ca, it may be expected that the ratio of exchangeable Ca to Mg or K would increase as base unsaturation proceeds. This may of course be true in the early stages of leaching. However, after this stage of soil formation is passed, greater amounts of Mg and so also K ions go into solution as a result of dissolution of primary minerals or breakdown of the exchange complex itself. Gedroiz [1916] and Hissink [1922] have pointed out that while a high percentage of exchangeable Ca is replaceable in the soil, this is neither true of Mg nor K. Potassium minerals are highly resistant to weathering and in addition K is a constituent of hydrous mica. Na and Mg minerals weather easily but Mg is present in the lattice framework of montmorillonitic clays and is removed only when the crystal lattice undergoes alteration. Mattson [1944] has demonstrated that Mg ions thus derived from the degradation of the lattice gradually take up exchange positions. The ratio of exchangeable Ca to Mg, therefore, tends to become less as degradation proceeds and the same is probably true of the ratio of exchangeable Ca to K.

As the hydrogen ions replace metallic cations, the *p*H of the soil decreases and the exchange complex tends to become increasingly unstable and this is specially true of montmorillonitic clays. Russell (*loc. cit.*) and so also Jenny (*loc. cit.*) attribute the cause of increasing acidity in the sequence to the formation of more of 2 : 1 expanding lattice type of minerals with drainage impedence and in consequence have a higher exchange capacity and hence a lower *p*H when unsaturated. The slightly higher silica-sesquioxide ratios and base exchange capacity of the clay fraction of the flats and lowlands in comparison to uplands might to a certain degree explain this phenomenon but the major factor contributing to increasing acidity in the lowlands appears to be the lower base status of the latter as revealed from the base : alumina ratios of the soil composition. Robinson [1930] observed characteristic changes when soil formation occurs under submerged conditions of drainage

accompanied by leaching. In presence of sufficient organic matter anaerobic decomposition occurs and a rapid increase in the solubilities of iron, manganese, magnesium and calcium takes place as hydrogen bicarbonates, and where leaching is possible, the dissolved bases may be lost with consequent impoverishment and lowering of the base status. The significant decrease in base : alumina, Ca : Mg and increase in alumina : iron oxide ratios indicate the progressive leaching of the bases and iron in the sequence. The Vindhyan flats and lowlands occurring towards the south of the plateau have been only partly cleared of their natural growths for cultivation and possess sufficient organic matter to augument the hydrolytic action of percolating waters through biological decomposition.

Turning attention now to the sequence in which the *p*H of the soil increases as the plateau is descended, i.e. in the soil type order 1, 3 and 5, it may be observed that the alkalinity rises rapidly as the drainage condition deteriorates and along with it the base status, exchangeable bases, silica : sesquioxide ratios and organic matter contents increase proportionately. The base unsaturation vanishes and the variation in exchangeable bases presents a characteristic pattern. Magnesium again assumes an important role as the soil formation proceeds towards gleization and salinization. In the process accompanying gleying, some Mg may be released due to hydrolytic decomposition of the exchange complex and which by taking exchange positions might be responsible for higher exchangeable Mg in poorly drained gleyey soils [Zavalishin, 1928]. Again in type 5 soils in which soluble salts accumulate in the subsoil and alkalinity is high, Mg and Na saturation increase significantly at the cost of Ca saturation. The upper horizons belong to a typical Ca soil highly saturated with exchangeable Ca ions. The salinization process has started in the subsoil and we find Mg first occupying the place of Ca and subsequently replaced by Na. Similar cases of high Mg accumulation have been observed in the process accompanying salinization and solodization by numerous workers [Kelley, 1948 ; Joffe, 1949 ; Hissink, 1938 ; Mukerji and Agarwal, 1947]. In such cases the greater solubility of Mg salts as compared to Ca salts at the prevailing *p*H so that the soil solution is largely a Mg-Na salt solution, might be responsible for the greater absorption of Mg in the exchange complex. The pedological role of exchangeable cations, particularly of Mg, in many soil evolutionary processes of either acidic or alkaline leaching is thus very characteristic.

In the earlier communication on Vindhyan soils (*loc. cit.*) it has been suggested that the process of soil formation governing the development of these soil is one typical of subtropical red loams. The data on base exchange of this great soil group are very scanty in soil literature to warrant a comparison with our soils. Terra rossas, said to be Mediterranean red earths on limestones, are highly Ca saturated soils. The red earth profile quoted by Joffe (*op. cit.*) from the region of the Russian Krasnozem is highly base unsaturated and should be an attribute of a podzolic process. The Vindhyan soils are not so highly base unsaturated although marked signs of degradation are noticeable in the profile characters and enough Mg and hydrogen have entered the exchange complex. These soils, therefore, definitely represent an advanced stage of maturity characteristic of typical red soils of the peninsular India.

Summary

The composition of exchangeable bases in the catenary soil sequence of the upper Vindhyan plateau in Uttar Pradesh have been studied. The exchange capacity of the soil increases with increasing amount of drainage impedence in the profile. The variation in exchangeable cations follow two extreme patterns. In one direction acidity increases in the sequence and exchangeable Ca is gradually replaced by Mg and H ions, while in another direction of increasing alkalinity, Ca saturation first rises and then decreases due to the process of gleization and salinization and is replaced by Mg and Na. The pedological aspects of exchangeable bases in the catenary sequence have been discussed and the cause of increasing acidity in the sequence has been attributed partly to the differences in the nature of the clay fraction but more in the base status of the soils arising out of varying drainage factors. The composition of exchangeable cations in the Vindhyan soils suggest an advanced stage of weathering and soil formation characteristic of typical red loams of subtropical climate.

Acknowledgement

The author thanks Dr. R. R. Agarwal, Agricultural Chemist to Government of Uttar Pradesh for his guidance.

REFERENCES

Agarwal, R. R., Mehrotra, C. L. and Gupta, R. N. (1957) Development and morphology of Vindhyan soils-I : Catenary relationship existing among the soils of the Upper Vindhyan plateau in Uttar Pradesh. *Indian J. Agric. Sci.* **27,** 395-411

Gedroiz, K. K. (1916). *The absorbing capacity of the soil and soil zeolitic bases.* Translated from Russian by S. A. Waksman

Gethin Jones, G. H. (1949). Colonial soil types : Systematic soil classification and nomenclature. *Common. Bur. Soil Sci. Tech. Commun.* **46**, 85-93

Hissink, D. J. (1922). Beitrag Zur Kenntnis der Adsorptionsvorgange in Boden, *Intern. Mitt. Bodenk.* **12**, 81-172

—— (1923). *Soil Sci.*, **15**, 269-276

—— (1938). Dutch saline soils. *Soil Sci.*, **45**, 83-94

Holmes, R. S., Hearn, W. E. and Byers, H. G. (1938). The chemical composition of soils and colloids of the Norfolk and related soil series. *U. S. Dept. Agric., Tech. Bull.* 594, Washington, D. C.

Jenny, H. (1941). *Factors of soil formation.* McGraw Hill Book Company Inc. Newyork and London.

Joffe, J. S. (1949). *Pedology*, 2nd Edition, Pedology Publication New Brunswick, New Jersey

Kelley, W. P. (1948). Cation Exchange in soils, *Amer. Chem. Soc. monograph* No. 109

Mattson *et al.* (1944). Electrochemistry of soil formation, VI Amphortric salts in relation to soil and peat formation and plant composition. *Ann. Agric. Col.* Sweden, **12**, 101-108

Mukerji, B. K. and Agarwal, R. R. (1947). Studies in the Gangetic alluvium of U. P.—II. Soils of Sandila tahsil in Hardoi district, *Indian J. Agric. Sci.*, **17**, 1

Parkar, F. W. (1929). The determination of exchangeable H in soils. *J. Amer. Soc. Agronomy*, **21**, 1021-1029

Robison, W. O. (1930). Changes occurring in submerged soils. *Soil Sci.*, **30**, 197-217

Russell, Sir E. John (1950). *Soil conditions and plant growth*, 8th edition, Longmans Green and Co., London.

Sigmond, A. A. J. De (1938). *The principles of soil science.* Thomas Murby and Co., London

Zavalishin, A. A. (1928). Some observations on the study of soils with a close Glei horizon. Pamyati K. D. Glinka (K. D. Glinka a memorial) Leningrad, *Sal'sko-Khoz. Inst.*, 45-90.

DEVELOPMENT STUDIES ON CROP PLANTS

III—INVESTIGATIONS ON CHARACTER DIFFERENCES INDUCED BY FERTILIZATION IN RELATION TO LODGING SUSCEPTIBILITY IN WHEAT CROP

By P. C. Raheja and K. P. Misra

[Received for publication on September 20, 1957
Accepted for publication on November 28, 1957]

IN India, fertilization of wheat crop is very largely conditioned by its susceptibility to lodging. In the wheat growing tracts, it generally happens that winter rains are preceded or followed by high winds. Heavy crops are unable to withstand the stress of wind velocity and in consequence lodge. For an Indian cultivator wheat straw, which is converted into *bhusa*, is quite an useful ingredient of farm animals' roughage. He has, therefore, a preference for medium to tall straw varieties. But generally such varieties have also inherent in them the susceptibility to lodging under adverse circumstances. In Western countries, notably Holland and Germany, short-straw varieties have been developed with a view to raise heavy grain yields without the hazard of lodging. Since breeding of lodging-resistant varieties is still an important aim, it is essential to study the effect of nutrients on characters which are responsible for susceptibility or otherwise of wheat to lodging.

Review of Literature

Interest in the study of lodging dates back to 1821 when Humphery Davy stated that silicon content of the epidermis was a factor of considerable importance in the strength of hollow plants. Later, Liebig [1861] stressed the importance of potassium silicate in the stem of grasses. Harcourt [1905] observed that lodging of oats was least on lime-treated soils and highest on those treated with nitrogen. Purvis [1919] working on orchard grass (*Dactylis glomerata*, L.) concluded that potash salts aided in the strengthening of culms. According to Welton [1928], lodging in cereals occurred because of decrease in the amount of dry matter and other reserve di-sacchrides and polysacchrides. In the condensation process of carbohydrates and possibly lignification in the culms, potassium plays an important role [David and Leclare, 1923]. Tubbs [1930] observed that deficiency of nitrogen increasingly strengthened lower internodes while deficiency of potassium had contrary effect but increased the strength of middle ones. The breaking strength of straw, in high nitrogen content plots, increased by 37·5 per cent [Gainey and Sewell, 1930]. Davidson and Phillips [1930] found that nitrogenous manures decreased the uptake of minerals other than nitrogen particularly silica and increased the lignin content in the plant body of cereals. Later on, Phillips, Davidson and Weihe [1931] reported that the weakness of the internodes is due to a loss of strength of the mechanical tissue for the production of which potassium is essential. Working on eight varieties of wheat, Welton and

Morris [1931] observed close correlation between the breaking strength of straw and their relative lodging performance. Davis and Stanton [1932] confirmed that stiff-strawed varieties had high resistance to breaking of straw. In general, Salmon's [1931] investigations indicated that lodging was a very complex phenomenon which depended on breaking strength of straw, length of culm, amount of grain produced per earhead and especially the particular type of plant subject to storm effect, due to which lodging occurred. Murphy [1944] reported that in various mixtures of fertilizers applied at 30 lb. per acre phosphate caused more lodging than others. However, contrary results were reported by Reitz and Myers [1944]. Krantz and Chandler [1951] found that potash-dressing decreased lodging in corn only in those cases where visual symptoms of potash deficiency occurred in the undressed plots. Mulder [1954] reviewed the phenomenon of lodging rather comprehensively and indicated that the favourable growing condition prevailing during the elongation of the lower culm internode gave rise to a crop with a high tendency of lodging. These growing conditions include supply of nutrient elements, particularly of nitrogen, water supply and temperature. He further found that in the majority of the cases under study, lodged cereal plants had bent and sometimes broken basal internodes. The application of nitrogen induced longer lower internodes than those grown in the same field with a moderate dose of nitrogen supply. Lodged plants dressed excessively with nitrogen had a less sturdy root system with less heavily lignified root. Potash deficient plants, in general, had shorter and thinner internodes than plants supplied normally with potash. Phosphorus deficient plants lodged less severely than those dressed amply with phosphate, apparently due to a poor development. The number of vascular bundles were less in phosphate deficient wheat plants. The reduction in grain yield ranged from 0 to 60 per cent. Thakur and Shands [1954] found that the application of nitrogen to wheat up to 60 lb. per acre in the form of ammonium nitrate increased the yield and simultaneously the tendency to lodging. The clipping of excessive growth induced resistance to lodging. Singh [1954] and Singh and Anant Rao [1954] observed that application of nitrogen beyond 75 lb. per acre progressively increased lodging in wheat and the reduction in grain yield noted was 49·2 per cent. Salt [1955] applied ammonium sulphate ranging from 0 to 4 cwt. per acre on different dates on wheat and found that the increase in nitrogen progressively induced lodging. Larson [1955] noted that the risk of lodging increased in wheat due to a larger application, e.g. 500-600 kg/hac. of fertilizer more particularly in forest region rather than in plains. Malkani and Vaidya [1956] studied the effect of application of nitrogen at 80 lb. per acre on the changes in the morphological characteristics of shoot and root on three different varieties of wheat C. 518, N. P. 165 and N. P. 12 in relation to lodging and observed that nitrogen application increased shoot/root ratio, length of lowest internode but decreased breaking strength, weight per unit length and number of cells in sclerenchyma and certain root characteristics. The breaking strength and shoot/root ratio, were found suitable indices of lodging.

In this experiment, effect of fertilization was studied in relation to lodging of the crop. The investigation had revealed that increasing doses of nitrogen caused increased lodging. Potash and calcium neither increased nor prevented lodging.

Phosphate in a dose of 80 lb. P_2O_5 per acre slightly induced more lodging, the increase not being significant even at 10 per cent level of significance [Raheja and Misra, 1954]. Further investigations were planned to study the contribution of the various plant characters to lodging in wheat.

Experimental

Treatments and layout

The treatments consisted of three levels each of nitrogen, phosphate, potash and lime. These were given per acre as shown below:

First digit	Nitrogen doses — lb. as ammonium sulphate	Phosphate doses — lb. as super	Second digit	Potash doses — lb. as sulphate of potash	Lime doses — md.
1	0	0	1	0	0
2	20	0	2	80	0
3	40	0	3	160	0
4	0	80	4	0	5
5	20	80	5	80	5
6	40	80	6	160	5
7	0	160	7	0	10
8	20	160	8	80	10
9	40	160	9	160	10

The layout plan of both the squares is given as under :

24	46	33	71	18	95	67	52	89	Remarks
55	85	42	23	57	14	79	91	38	
75	34	81	62	99	56	28	13	47	
41	93	59	37	65	22	84	78	16	Confounding
58	77	64	15	43	39	92	86	21	Rows—ACD-W
97	29	76	54	82	48	11	35	63	ABC-X
19	68	25	96	31	87	53	44	72	BCD-Y
83	12	98	49	74	61	36	27	55	ABD-Z
32	51	17	88	26	73	45	69	94	Columns : ABC(Y)
77	43	92	15	86	64	58	21	39	ACD(X)
29	82	11	54	35	76	97	63	48	ABD(W)
85	57	79	23	99	42	66	38	14	BCD(Z)
93	65	84	37	78	59	41	16	22	
12	74	36	49	27	98	83	55	61	
34	99	28	62	13	81	75	47	56	
51	26	45	88	69	17	32	94	73	
68	31	53	96	44	25	19	72	87	
46	18	67	71	52	33	24	89	95	

(*a*) *Number of coronal roots per plant.* The anchorage provided by the coronal roots is an important factor in resisting mass falling as a result of rank growth, storms or inherently weak stem. In the analysis of variance, this effect of the main nutrients and their combination has been clearly brought out in Table I.

TABLE I

Analysis of variance for different morphological characters

(Calculated on the basis of five plants)

Due to	D.F.	(a) Mean No. of coronal roots: Mean Square	(a) Cal. ratio	(b) Mean weight of earheads in gm.: Mean Square	(b) Cal. ratio	(c) Mean weight of culms in gm.: Mean Square	(c) Cal. ratio	(d) Mean length of culms in cm.: Mean Square	(d) Cal. ratio.	(e) Mean number of culms: Mean Square	(e) Cal. ratio	(f) Expected value of 'F': 5 per cent	(f) 1 per cent
Blocks	1	2970·20	..	78·56	..	48·67	..	704·02	..	211·17	..	3·96	6·98
Rows	16	36284·13	..	1226·38	..	490·76	..	7627·07	..	2106·12	..	1·80	2·30
Columns	16	37177·83	..	1229·81	..	370·82	..	7928·90	..	2113·77	..	1·80	2·30
N	2	704·55	..	144·19	3·87*	203·87	5·66*	1063·69	5·72**	97·88	1·31	3·11	4·89
P	2	4837·05	2·12	149·78	4·02*	124·99	3·47*	179·93	0·97	102·19	1·37	3·11	4·89
K	2	933·50	9·45	65·57	1·76	55·83	1·55	167·58	0·90	81·66	1·09	3·11	4·89
Ca	2	7380·24	3·53*	67·44	1·81	59·79	1·66	109·36	0·59	88·12	1·18	3·11	4·89
NxP	4	1637·19	0·79	108·79	2·92*	108·78	3·02*	363·47	1·95	81·22	1·09	2·48	3·57
NxK	4	1402·12	0·72	47·79	1·28	99·41	2·76*	378·34	2·03	47·88	0·64	2·48	3·57
NxCa	4	2613·94	1·27	103·21	2·77*	93·29	2·59*	402·19	2·16	48·72	0·64	2·48	3·57
PxK	4	1284·88	0·62	71·53	1·92	27·73	0·77	119·95	0·64	53·16	0·71	2·48	3·57
PxCa	4	2357·28	1·62	99·48	2·67*	34·58	0·96	153·46	0·83	159·62	1·14	2·48	3·57
KxCa	4	3688·87	1·68	29·06	0·78*	10·44	0·29	127·00	0·68	67·18	0·90	2·48	3·57
Uncon- NxPxK	4	393·75	0·19	23·01	0·62	27·37	0·76	171·10	0·92	35·19	0·47	2·48	3·57
founded NxPxCa	4	580·27	0·28	17·88	0·48	31·70	0·88	111·13	0·60	47·16	0·63	2·48	3·57
NxKxCa	4	3647·42	1·76	28·69	0·77	25·93	0·72	67·03	0·36	57·62	0·77	2·48	3·57
PxKxCa	4	2466·15	1·19	30·18	0·81	6·12	0·17	74·08	0·40	62·88	0·84	2·48	3·57
NxPxKxCa	16	2196·74	..	26·45	0·71	18·73	0·52	107·60	0·58	78·63	1·05	1·80	2·30
Error	64	2072·40	..	37·26	..	36·02	..	185·92	..	74·52	..	..	..
TOTAL	161	..	..	..	..	..	..	..	..	..	..	..	..
		S. Em for main effects (for single plant) = ±1·27 C.D. 5% = 3·54 S. Em for 2 factor interaction = ±2·14		S. Em for single plant : main effects = % = 0·17 C.D. 5% = 0·48 C.D. 1% = 0·64 S. Em for 2 factor interaction = ±0·29 C.D. 5 = ± 0·82		S. Em for single plant : main effects = ±0·16 C.D. 5% = 0·45E C.D. 5% = 0·54 S. Em for 2 factor interaction = ±0·28 C.D. 5 % = 0·80		S. Em for main effects = ±1·86 C.D. 5 % = 5·26 1 = % = 6·99 S. Em for 2 factor interaction = ±3·21 % = 0·60		S. Em for single plant (for main effects) = ±0·23 S. Em for two factor interaction = ±0·41			

*indicates significance at 5 per cent level.
**indicates significance at 1 per cent level.

The effect of application of phosphate was not significant although application of a dose of 160 lb. P_2O_5 per acre was somewhat responsible for the development of coronal roots. The effect of 80 lb. P_2O_5 dose was evident to a lesser extent (Table II).

TABLE II

Average of coronal roots per plant

Nitrogen doses	No. of roots	Phosphate doses	No. of roots	Potash doses	No. of doses	Lime doses	No. of roots
N_0	27·31	P_0	25·30	K_0	26·55	Ca_0	25·79
N_{20}	26·31	P_{80}	27·20	K_{80}	28·09	Ca_5	25·80
N_{40}	27·76	P_{160}	28·91	K_{160}	26·77	Ca_{10}	29·89
F' test	Not sig.		Not sig.		Not sig.		Sig 5%
S.Em	±1·27		±1·27		±1·27		±1·27
C.D. 5 per cent	—		—		—		3·54

Application of lime at 10 md. per acre increased the coronal roots significantly over other doses. The effect of nitrogen, potash and the various treatment combinations was indicated to a very small extent.

(*b*) *Average weight of earhead.* The crop of wheat usually lodges when earheads have appeared but are still immature. The emergence of earheads brings about top heaviness and, therefore, imbalance for the plants. The centre of gravity shifts and the mass falling of plant occurs with a storm. Therefore, differences in development of earheads due to various nutrients indicates the indirect effect of nutrients favouring lodging of the crop.

From the analysis of variance (Table I), it is observed that the application of nitrogen and phosphate had a significant effect on the development of earheads. The weight of earheads, by application of 20 and 40 lb. N doses, was significantly greater than without application of nitrogen. The weight of earhead with phosphate

doses also increased significantly over control. The interaction of N and P also indicated significant effect. The data for mean values of the interactions is given in Table III.

TABLE III

Combined influence of nitrogen and phosphate on weight of earheads per plant (gm.)

Doses of nitrogen	Doses of phosphate P_0	P_{80}	P_{160}	Mean	Main effects	Two factor combinations
N_0	4·48	4·75	4·93	4·69	SEm ± 0·17	±0·29
N_{20}	4·50	5·66	5·41	5·19	C.D. at 5%	
N_{40}	5·21	5·34	5·09	5·21	0·48	0·82
Mean	4·68	5·30	5·11	5·03		

The dose N_{20} P_{80} has indicated the maximum effect and is significant over N_0 P_0 and N_0 P_{80}.

Although application of lime had less appreciable effect upon increase in weight of earhead but combined with nitrogen or phosphate, lime significantly increased the earhead weight. This is obvious from the data given in Table IV.

TABLE IV

The influence of lime and nitrogen or phosphate on the average weight of earhead per plant (gm.)

Doses of nitrogen	Doses of lime Ca_0	Ca_5	Ca_{10}	Remarks
N_0	4·30	4·98	4·78	The figure in parenthesis is an interpolated one
N_{20}	5·12	4·81 (5·38)	5·64	
N_{40}	5·11	5·38	5·14	
P_0	4·58	4·69	4·77	
P_{80}	4·98	5·28	5·64	N×Ca and P×Ca combination SEm=±0·29
P_{160}	4·96	5·23	5·14	C.D. at 5 per cent =0·82

The application of lime in combination with nitrogen or phosphate increased the mean weight of earheads per plant. A dose of 10 md. of lime either with 20 lb. N or with 80 lb. P_2O_5 increased the earhead weight very appreciably. The influence of higher doses was less marked in combination with 5 md. or 10 md. of lime per acre.

(c) *The average weight of culms.* Prior to heading, temporary lodging may occur in wheat crop before the culms are fully developed. Usually, these culms recover as they have elasticity and are in a state of vigorous growth. The culms grow out on the lower side of the nodes which turn the stems upward. Sometimes, this temporary lodging causes damage to the ear in formation within the sheath. After heading, the weightiness of culms adds to the top-heaviness of the plants and contributes towards lodging of the crop. Therefore, differences due to the effect of nutrients were studied by the analysis of variance of the average weight of culm data obtained in the series (Table I). The analysis indicated that differences due to nitrogen doses, phosphate doses and the interactions NP, NK and NCa were significant. The mean values are given in Table V.

TABLE V

Mean weight of culms (without earheads) per plant (gm.)

Nitrogen doses	Phosphate doses P_0 P_{80} P_{160}	Potash doses K_0 K_{80} K_{160}	Doses of lime Ca_0 Ca_5 Ca_{10}	Mean	Main effects	Two factor combination
N_0	3·89 4·34 4·18	3·78 4·13 4·50	3·63 4·67 4·07	4·14	SEm±0·16	±0·28
N_{20}	4·18 5·32 4·94	4·66 5·04 4·74	4·91 4·64 4·86	4·81	C.D. 0·45 at 5%	0·80
N_{40}	4·94 4·90 4·65	5·06 4·63 4·79	4·53 4·87 5·09	4·83		
Mean	4·34 4·85 4·59	4·50 4·60 4·68	4·54 4·74 4·68	4·59		

The dressings with nitrogen at 20 and 40 lb. levels respectively, increased the weight of culm significantly over no nitrogen dressing, the difference between the two doses being not significant. The application of 80 lb. dose of phosphate produced culms of higher weight than no-phosphate treatment. The difference in weight of culms with 160 lb. P_2O_5 dose and no phosphate treatment was not significant. The maximum response has been indicated by the interactions NP followed by NK and NCa.

The following doses amongst the different interactions indicated beneficial effect :

NP . . . . N_{20} P_{80}, N_{40} P_{80} N_{20} P_{10}

NK . . . . N_{40} K_0, N_{20} K_{20}

NCa . . . . N_{40} Ca_{10}, N_{50} Ca N_{20} Ca_{10}

All these exhibited significantly higher weight of culm than the controls N_0P_0 N_0K_0 and N_0Co_0 respectively.

Although nitrogen in combination with the doses of potash and lime increased the culms' weight, the order of increase has not indicated that increasing doses of these nutrients along with increasing doses of nitrogen increased the culm weight.

(*d*) *Mean length of culm.* Length of culm is an important factor in the lodging of cereals. The longer the culm length the greater is the shift of centre of gravity and smaller the force required to bring about mass falling off of the crop. It is, therefore, essential to investigate what nutrients tend to greater lengthening of culms and *vice versa*. The data in Table VI summarizes the effect of various nutrients on culm length.

TABLE VI

Average length of culm as affected by various main treatment

Nitrogen doses	Culm length (cm.)	Phosphate doses	Culm length (cm.)	Potash doses	Culm length (cm.)	Lime doses	Culm length (cm.)
N_0	86·00	P_0	88·98	K_0	88·92	Ca_0	88·95
N_{20}	87·22	P_{80}	89·02	K_{80}	89.05	Ca_5	88·97
N_{40}	93·71	P_{160}	88·93	K_{160}	88·99	Ca_{10}	89·01
'F' test	Sig. 1%		Not sig.		Not sig.		Not sig.
S. Em:	±1·86		±1·86		±1·86		±1·86
C.D. 5%	5·21	—		—		—	

The analysis showed that nitrogen had the maximum effect in increasing the culm length. Double dose of nitrogen significantly increased the mean length of the culm over single dose of nitrogen or no-nitrogen application. Application of phosphate had small effect on culm increase and that of potash and lime still less. In combination with nitrogen, these nutrients did not significantly increase the culm length

(*e*) *Average number of tillers per plant.* Tillering contributes very appreciably to the yield of the crop. The heavier the crop the greater is its tendency to lodging. This factor was, therefore, investigated in its relation to the differential manuring of the crop. The analysis of variance of the data are given in Table I.

It is obvious from the analysis that tillering was little affected by differential manuring. Neither the main treatments nor the combination have had effect to any large extent on tiller production. (Table VII).

TABLE VII

Average number of tillers per plant in relation to main treatments

Nitrogen doses	Tiller No.	Phosphate doses	Tiller No.	Potash doses	Tiller No.	Lime doses	Tiller No.
N_0	3·35	P_0	3·24	K_0	3·47	Ca_0	3·37
N_{20}	3·60	P_{50}	3·72	K°_{0}	3·50	Ca_5	3·39
N_{40}	3·52	P_{100}	3·51	$K\ 1_{60}$	3·52	Ca_{10}	3·71
'F' test	Not sig.		Not sig.		Not sig.	Not sig.	
SEm	±0·23		±0·23		±0·23	±0·23	

Significance of results. There are two types of lodging which occur in wheat crop. The plants usually recover from temporary lodging which occasionally occurs before the culm formation is far advanced in growth. The permanent lodging occurs at a stage when the culms have lost their elasticity and the earheads have either reached the stage of boenting or have completely emerged. It is at this stage that fertilization of ovules takes place and grain formation sets in. The falling off of the culms, at this time, impedes the supply of water and transference of nutrients into the embryo. This falling off is reduced if the plant has a firm hold on the soil or the plant is less top-heavy. There are various characters which are associated with top-heaviness of the wheat plant, and these are weight of earheads, number of culms, weight of culms and height of culm. In the investigations reported in the preceding text the various nutrients have exhibited differential effect on the development of the characters. By far and large is the effect of nitrogen on the development of the plant parts, such as the weight of earheads, weight of culms and mean length of culm. The effect of nitrogen on the number of coronal roots and tillering was not exhibited. Phosphate doses beneficially influenced the weight of earheads and weight of culm. The interaction effect of nitrogen and phosphate was significantly evident on the weight of earheads and weight of culm.

The application of lime significantly increased the number of coronal roots but had little effect upon the development of other characters of the plant. The interaction for the combination NxCa was significant only for earhead weight which indicates that lime influences earhead weight and culm weight in conjunction with nitrogen and earhead weight in conjunction with phosphate also.

These studies, therefore, indicate that tall growing varieties should not be heavily manured with nitrogen, for such varieties have predisposition to lodging. This is aggravated owing to increased earhead weight, height of culms and mean weight of culms by application of nitrogen and phosphate.

Summary

Biometrical observations were recorded on sample plants from all the 162 plots of $(3)^4$ confounded design N.P.K.Ca experiment. The observations were recorded on number of coronal roots, height of culms, weight of earheads, number and weight of culms per plant. The results are summarised as under :

1. The weight of earheads per plant was beneficially influenced by application of nitrogen, phosphate and the treatment combinations NP, NCa and PCa. Dose of 10 md. of lime either with 20 lb. N or 80 lb. P_2O_5 increased the weight of earheads.

2. The nitrogen doses of 20 and 40 lb. and phosphate dose of 80 lb. increased the average weight of culm significantly over the control treatment. The interactions NP, NK and NCa were also significant.

3. Nitrogen factor alone significantly increased the culm length when applied at the rate of 40 lb. N per acre.

4. Application of lime at the rate of 10 md. per acre induced significantly greater development of coronal roots. Other nutrients exhibited less pronounced effect.

In general, the analysis has indicated that the nitrogen application at an increasing rate is a pre-disposing factor to increased lodging by increasing the weight of earheads per plant, number and weight of the culms and the mean height of the culm.

Acknowledgement

The authors are grateful to Dr. B. P. Pal, Director, Indian Agricultural Research Institute, New Delhi, for providing the necessary facilities for conducting these investigations. They are also grateful to Dr. P. N. Saxena and Shri Daljit Singh for advice regarding the statistical analysis of the data.

REFERENCES

Davidson, J. and Phillips, M. (1930). Lignin as a possible factor in lodging of cereals, *Science*, **72**. 401-402

Davis, L. L. and Stanton, T. R. (1932). Studies on the breaking strength of oats at Aberdeen, Idaho. *J. Amer. Soc. Agron.* **24.** *290*

Davy H. (1821). *Elements of Agricultural Chemistry. 3rd Ed.*

Gainey, P. L. and Sewell, M. C. (1930). Indications that available N may be a limiting factor in hard winter wheat production. *J. Amer. Soc. Agron.* **22**, 639

Harcourt, R. (1905). Lodged grain : *Ann. Rept. Ontario Agric. College Expt. Sta. Rec. :* **17**, 856

Krantz, B. A. and Chandler, W. V. (1951). Lodging, leaf composition and yield of corn as influenced by heavy application of N and K. *Agron. J. ;* **43**, 547-552

Larson, C. (1955). Trial with increasing amount of N fertilization, I : Nitrogen and fertilization of cereals. *Soils* and *Fert.* **19**(3)

Liebig, Justus Von. (1861). *Chemistry and its application to agriculture and Physiology, 4th Ed.*

Malkani T. J. and S. M. Vaidya. (1956). Morphological characteristics of shoot and root in relation to lodging in three varieties of wheat. *Indian Genet. and Plant breeding ;* **16**(2)

Mulder E. G. (1954). Effect of mineral nutrition on lodging of cereals. *Plant and Soil ;* **5**, 246-306

Phillips, M., Davidson, J. and Weihe, H. D. (1931). Studies of lignin in wheat straw with reference to lodging. *J. Agric. Res.* **43**, 610

Purvis, G. N. (1919). The effect of K salts on anatomy of *Dactylis glomerata*, L. *J. Agric. Sci.*, **9** : 338-365

Raheja, P. C. and Misra, M. D., (1954). Development studies in crop plants : I. Influence of nitrogen phosphate, potash and calcium alone and in combination on wheat. *Indian J. Agric. Sci.* **25**(2)87-104

Salmon, S. C. (1931). An instrument for determining the breaking strength of straw and preliminary report on the relation between breaking strength of straw and lodging : *J. Agric. Res.*, **43**, 73-8

Salt, G. A. (1955). Effect of nitrogen applied at different dates and other cultural treatments on the eye-spot, lodging and yield of wheat. *J. Agric Sci.*, **46**, 407-416

Singh, R. (1954). Effect of excessive N manuring on the lodging and yield of wheat. *Curr. Sci.*, **23**, 199-200

Singh, R. and Anant Rao N. K. (1954). Studies on the excess manuring of wheat. *Agra Univ. J. Res. and Sci.* **3**, 499-508

Thakur, C. and Shands, H. L. (1954). Agronomic response of spring wheat to plant-clipping when seeded at two rates and fertilizers at two levels of nitrogen : *Agron. J.* **46**, 15-19

Tubbs, F. R., (1930). Physiological studies in plant nutrition II : The effect of manurial deficiency on the mechanical strength of barley straw : *Ann. Bot.* **44** : 147-60

Welton F. A (1928). Lodging in wheat and oats : *Bot. Gaz.*, **85**, 121-51

Welton F. A. and Morris, V. H. (1931). Lodging in oats and wheat. *Ohio Agric. Sta. Bull.*, **4**, 71.

EFFECT OF TILLAGE AND SOURCE OF NITROGEN ON THE YIELD OF WHEAT

By B. D. Ganguly and L. L. Relwani, Agricultural Research Substation, Karnal (Punjab)

[Received for publication on May 25, 1953
Accepted for publication on September 18, 1957]

PREPARATION of seed-bed is probably the most laborious operation in agriculture and more so in the case of wheat crop among the cereals. The object of preparatory tillage by different implements is the same, viz. to loosen the soil for aeration, absorption and retention of moisture, destruction of weeds and creation of fine tilth for sowing.

In India, the fields are generally ploughed by traditional method of bullock drawn indigenous implements which merely stir the soils without turning them upside down. Progressive cultivators usually do the initial ploughing by bullock drawn light soil inversion ploughs to bury weeds, stubbles and other surface trash into the soil and also to expose the subsoil layer to the beneficial effects of weathering by sun, air and rain. The use of power tractors and allied implements is also being made ; the land is opened with soil inversion ploughs and further preparation done by disc harrows and grubbers till a fine crumb structure of the seed-bed is obtained.

This experiment was in continuation of the one reported earlier by Khan [1953] who found the superiority of tractor ploughing in a soil badly infested with pernicious weeds specially those of *Sorghum halepense* (barru) and *Convolvulus arvensis*(lepatni) in the first two years. During subsequent years, however, shallow inversion by bullock implements outyielded the former. Under weedy conditions, cultivation by country plough proved unsuccessful.

In the present investigation the site was shifted to an area where deep rooted weeds did not exist.

The efficiency of nitrogen from two sources, viz. farmyard manure and sulphate of ammonia was also simultaneously studied to determine the most suitable cultural-*cum*-manurial combination for wheat crop.

Experimental

The experiment includes data for four years from 1949-50 to 1952-53. The layout consisted of three cultural and four manurial treatments in a split plot design with four replications. The size of sub-plot was 0·24 acre and that of the main plot 0·96 acre. The experiment was located in Block 5 W. in the first year and adjacent Block 5E. in the remaining three years.

Treatments :

(*a*) *Cultural* (*main plot*)

X—Tractor plough

Y—Victory (bullock drawn inversion plough)-*cum*-country plough (non-inversion)

Z—Country plough (non-inversion)

(*b*) *Manurial* (*sub plot*)

A—No manure

B—Ammonium sulphate at 60 lb. N per acre

C—F.Y.M. at 60 lb. N per acre

D—Ammonium sulphate at 30 lb. N per acre plus F.Y.M. at 30 lb. N per acre.

Wheat variety N.P. 165 was grown. Single year rotation, viz. fallow-wheat was followed. The soil consisted of an old alluvium known as *bhangar* with the following chemical and mechanical analyses :

Depth from surface	Total nitrogen	Organic carbon	Total P_2O_5	Available P_2O_5	Total K_{20}	Available K_{20}
0·6 inches	0·099	0·79	0·182	0·025	1·44	0·04
6·12 inches	0·062	0·58	0·169	0·025	1·28	0·034

Mechanical constituents (*per cent*)

Depth from surface	*Sand*	*Silt*	*Clay*
0·6 inches	58·2	14·0	27·8
6·12 inches	57·8	12·4	29·8

The above analyses point to the loamy texture of the soil, well supplied with plant nutrients and thus ideally suited for wheat cultivation.

Cultural treatments

The idea underlying the preparation of seed-bed with different implements was to create a uniform tilth, ideal for sowing seeds. The number of operations under each cultural treatment varied according to the efficiency of the implement. Number of cultivations given for each cultural treatment for preparing the seed-bed are given in Table I.

TABLE I

Number of cultivations given for preparing seed-bed, in different years

Year	Tractor			Victory-*cum*-Country		Country
	Plough	Cultivator	Disc	Victory plough	Country plough	Country plough
1949-50	1	2	2	1	5	8
1950-51	1	—	4	1	7	10
1951-52	1	3	—	1	4	6
1952-53	1	1	2	1	6	9
Mean for four years	1·0	1·5	2·0	1·0	5·5	8·3

Table I shows that for 4·5 operations by tractor and allied implements, 6·5 by 'Victory-*cum*-Country' and 8·3 by 'Country' ploughs were found necessary to prepare the seed-bed to correct tilth.

Manurial treatments

Farmyard manure was applied a month to month and-a-half before sowing and sulphate of ammonia at the time of sowing wheat.

Experimental Results

Cultural

Yields of wheat grain obtained during four years from 1949-50 to 1952-53 are given in Table II.

Table II

Average yield of wheat grain in maunds per acre

Treatment	1949-50	1950-51	1951-52	1952-53	Mean
X	10·21	14·58	19·52	16·85	15·29
Y	10·55	12·37	19·74	16·95	14·90
Y	9·07	15·65	17·98	16·37	14·77
Mean	9·94	14·20	19·08	16·72	
F-test	Not Sig.	Not Sig.	Not Sig.	Not Sig.	Not Sig.
S.Em.	±1·03	±1·56	±0·75	±1·41	±0·79

The wheat yield data show that every year, i.e. from 1949-50 to 1952-53, there were no significant differences among the three types of tillage for preparing seed-bed. Also the cumulative effects of cultivation of the last three years were not significant. This proves that tractor implements or improved bullock drawn inversion plough by themselves do not help in significantly increasing the acre yields of wheat over the traditional method of preparing seed-bed by shallow non-inverting ploughs. However, the economics of cultivation favour the tractor followed by 'Victory-*cum*-Country' treatments over the Country treatments as represented in Table III.

Table III

Economics of seed-bed preparation by different implements per acre

Type of tillage	Cost of seed-bed preparation*	Value of produce (grain+*bhusa*)†	Value of produce less cost of seed-bed preparation	Net profit over Country tillage
Tractor	25·75	382·27	356·52	45·35
Victory-*cum*-Country	47·25	372·50	325·25	14·08
Country	58·10	369·27	311·17	—

* Tractor-ploughing at Rs. 10, disc harrowing and cultivating at Rs. 4·50 each. Victory ploughing at Rs. 8·75 and Country ploughing at Rs. 7·00 per acre.

† Wheat grain at Rs. 15 per maund. Wheat *bhusa* at Rs. 4 per maund.

Apart from a substantial profit of Rs. 45·35 by mechanical cultivation over country ploughing, it provides a good deal of saving in the time required to prepare seed-bed. A 45·0 H.P. tractor on an average ploughed 0·8 acre and cultivated or disc harrowed two acres per hour, respectively. Thus only 3·0 hours were required to finish 1·0 ploughing, 2·0 disc harrowings and 1·5 grubbings (cultivatings) as against 55 hours (10 hours for victory ploughing and 45·0 hours for 5·5 country ploughings) by 'Victory-*cum*-Country' treatment and 66 hours (8·3 ploughings at the rate of 8 hours per ploughing) by 'Country' treatment. It is, therefore, evident that in the matter of speed of cultivation, tractor cultivation was 18 and 22 times more efficient than 'Victory-*cum*-Country' and 'Country' types of tillage, respectively.

Manurial

TABLE IV

Average yield of grain in maunds per acre

Treatment	1949-50	1950-51	1951-52	1952-53	Mean
A	5·65	10·34	16·11	13·54	11·41
B	13·52	16·47	21·44	20·26	17·92
C	8·14	13·37	18·93	15·22	13·92
D	12·43	16·62	19·85	17·87	16·69
Mean	9·94	14·20	19·08	16·72	
F-test	Sig.	Sig.	Sig.	Sig.	Sig.
S. Em.	±0·61	±0·84	±0·58	±0·45	±0·31
C. D. at 5%	1·78	2·44	1·68	1·31	0·91
C. D. at 1%	2·41	3·29	2·26	1·76	1·23

The results presented above give a convincing evidence that every year ammonium sulphate proved to be significantly superior to F.Y.M. The mean yield for four years show that it produced 4·0 md. per acre more grain than F.Y.M.

The mixture occupied a place nearer to ammonium sulphate than F.Y.M. and was statistically at par with ammonium sulphate during first three years and significantly superior to F.Y.M. in the first, second and fourth years. F.Y.M. in its turn was significantly superior to 'no-manure' every year. The results further reveal that F.Y.M. or mixture of F.Y.M. and ammonium sulphate did not exhibit cumulative effects as seen from the yield figures of 1950-51 and 1952-53.

Interaction

Interactions, cultural treatments × manurial treatments and cultural treatments × manurial treatments × years were found to be not significant.

TABLE V

Economics of manuring

Treatment	Cost per 60 lb. N*	Value of produce (grain+ *bhusa*)	Cost of extra produce over 'no manure' †	Value of produce less amounts in columns 2 & 4	Profit over 'no-manure'
	Rs.	Rs.	Rs.	Rs.	Rs.
Ammonium sulphate	49·55	448·00	13·02	385·43	100·18
F. Y. M.	45·54	348·00	5·02	297·44	12·19
Ammonium sulphate and F.Y.M. mixture	47·54	417·25	10·56	359·15	73·90
No manure	..	285·25	..	285·25	..

* F Y.M. at Rs. 5·0 loading and carting at Rs. 2·0 and spreading at Rs. 1·5 per ton respectively. Nitrogen content of F.Y.M.—0·50 per cent. Ammonium sulphate at Rs. 364·0, loading and carting at Rs. 2·00 and spreading at Rs. 4·00 per ton, respectively. Nitrogen content of ammonium sulphate—20·0 per cent.

† Harvesting and threshing at Rs. 2·0 per maund of grain.

The data show that ammonium sulphate produced an excess profit of Rs. 87·99 and Rs. 26·28 over F.Y.M. and mixture of F.Y.M. and ammonium sulphate respectively. In fact F.Y.M. at 60 lb. N produced just a little more return than the expenditure involved in its application. Thus, both from yield and economic points of view, ammonium sulphate proved to be superior to F.Y.M.

Discussion

In the present paper an attempt has been made to study the effects of preparing seed-bed by tractor and allied implements, viz. cultivator and disc, bullock drawn 'Victory' inversion plough supplemented by non-inversion Country plough and only Country plough on the yield of wheat in a monoculture. The effects were further tested in combination with nitrogen from organic (F.Y.M.) and inorganic (ammonium sulphate) sources. Mixture of the two was also used in equal proportions to see if one rendered the other more effective. The yield data for four years from 1949-50 to 1952-53 indicate that every year the wheat yield differences were non-significant due to cultivation operations whether by tractor or bullock drawn implements. Stewart [1947] in the soil fertility investigations in India made a general conclusion that where the standard of cultivation by country implements was high, the use of improved implements had no significant effect on crop yields. According to him the main purpose of cultivation under Indian conditions appeared to be the control of weeds and provided the land was kept free from weeds, it made little difference to crop yield whether country implements or improved implements were used. Zobell [1936], Faulkner [1948], Russel and Kèen [1940], Khan and Mathur [1952] have also expressed views in favour of shallow ploughing. Khan [1953], however, contends that shallow depths without inversion under weedy conditions did not produce satisfactory yields. Since the present site was free from any appreciable weed growth, soil inversion by bullock drawn 'Victory', or tractor ploughs did not improve the yields of wheat over 'Country' plough. It can, however, be seen that in the case of tractor ploughing, only 4·5 cultivations were required to prepare a seed-bed instead of 6·5 and 8·3 operations as in the case 'Victory-*cum*-Country' and only 'Country' ploughs, respectively. Similarly, in the matter of economics and speed of operations, tractor cultivation produced substantial advantage over bullock-drawn implements.

The manurial treatments favour the use of ammonium sulphate more than F.Y.M. which seems to be rather slow acting and unable to release its organic nitrogen into available form during the critical period of growth of the crop. Ammonium sulphate, on the other hand, is a quick acting fertilizer and, therefore, its nitrogen is utilized for growth from the very seedling stage. These results are in conformity with the findings of Chandnani [1954] who found that in case of wheat, F.Y.M. had a little manurial value if applied in doses of less than 10-15 tons or 100 lb. N. per acre. The average responses for 60 lb. N dose for four years from ammonium sulphate, F.Y.M. and their mixture in equal proportions were 8·9, 3·4 and 7·2 lb. of grain per lb. of nitrogen, respectively. Thus the extent of response was higher in the case of ammonium sulphate than F.Y.M. or their mixture.

Summary

Effects of three cultivation treatments, viz. tractor and allied implements, bullock drawn 'Victory' inversion plough-*cum*-non-inversion Country plough and only Country plough for seed-bed preparation on the yield of wheat were studied.

These cultural operations were combined with nitrogen at 60 lb. N per acre from organic (F.Y.M.) and inorganic (ammonium sulphate) and their mixture in equal proportions. The results showed that (*a*) there were no significant differences in yield of wheat due to different methods of cultivation, (*b*) seed-bed preparation by tractor and allied implements, Victory-*cum*-Country and only Country ploughs required 4·5, 6·5 and 8·3 operations, respectively, (*c*) in the matter of speed of operations, tractor cultivation was 18 and 22 times more efficient than 'Victory-*cum*-Country' and Country treatments, respectively, (*d*) cultivation by tractor was more economical in the long run than with bullock-drawn implements and (*e*) among the manurial treatments, nitrogen from the inorganic source (ammonium sulphate) proved more efficient and economical than the organic source (F.Y.M.). The mixture of the two forms occupied a position nearer to ammonium sulphate than F.Y.M.

Acknowledgement

The authors gratefully acknowledge the help and guidance of Dr. T. J. Mirchandani and Dr. P. C. Raheja throughout the progress of the work. They also thank Shri A. R. Khan for his helpful criticism and Dr. P. N. Saxena for the statistical analyses of the experimental data.

REFERENCES

Chandnani, J. J. (1954). Manuring of wheat. *Indian J. agric. Sci.* **24** (4) : 195-211

Faulkner, E. H. (1948). *Ploughing in prejudices* : 26-27

Khan, A. R. and Mathur, B. P. (1952). Ploughing is manuring. *Indian Fmg.* **11**(9) : 14-15

Khan, A. R. (1953). Studies on tillage. *Indian J. agric. Sci.* **23**(2) : 131-137

Russel, E. J. and Keen, B. A. (1940). Some ploughing experiments. *Madras Agric. J.* **27**

Stewart, A. B. (1947). *Report on the soil fertility investigations in India.* Delhi Army Press : 33

Zob[illegible], I. D. (1936). Soil management and crop production studies. *Utah Agri. Expt. Sta. Bull.* **27** : 10.

CHEMICAL COMPOSITION OF CIGAR TOBACCO LEAF AS INFLUENCED BY ITS POSITION ON THE STALK

By K. G. Tejwani,[1] C. K. Ramakrishna Kurup[2] and K. V. Venkataraman[3]

[Received for publication on July 27, 1957
Accepted for publication on September 16, 1957]

(With 2 text-figures)

SEVERAL investigators have studied the variations in the chemical composition of the tobacco leaf as influenced by its position on the stalk [Anderson *et al.*, 1939 and Hanmer *et al.*, 1940 in Connecticut cigar tobacco ; Bowman *et al.*, 1953 in Burley tobacco ; Darkis *et al.*, 1936 ; Askew *et al.*, 1947 in flue-cured tobacco and Garner *et al.*, 1934 in Maryland tobacco]. The necessity for such a study on a typical Indian cigar tobacco type was felt in view of the differences in soil and climatic factors and in the methods of curing and fermentation adopted in South India. A study of the chemical composition of the leaf as influenced by its position on the stalk was, therefore, undertaken as part of a general study on leaf position, at the Cigar and Cheroot Tobacco Research Station, Vedasandur. The data pertaining to the growth and quality have been reported in a previous paper [1957].

Experimental

Details of the experimental methods were given in a previous communication. The leaf samples for chemical analysis were taken at the time of stripping (separation of leaf from the stalk), after the end of curing and fermentation. A composite sample of 40 leaves from each leaf position (ten leaves from each replication) were taken for chemical analysis and were dried in a steam oven at 95°C., powdered and sieved through a 0·5 mm. sieve.

Nitrogen, phosphorus, calcium, magnesium and sulphur were estimated by the official methods (A.O.A.C. 1950) ; sodium and potassium by the methods recommended by Piper [1947] and nicotine by the improved steam distillation apparatus suggested by Griffith and Jeffrey [1948].

Results and Discussion

The results of the analysis of 1952-53 and 1953-54 samples are presented in Table I.

It is observed that the different constituents exhibit a definite trend and either increase or decrease from the bottom to the top of the plant. In order to judge the trend in variation of the different chemical constituents, regression equations were

[1] and [3] Pedologist and Pedological Assistant respectively at the Central Tobacco Research Institute, Rajahmundry.

[2] Chemical Assistant, Cigar and Cheroot Tobacco Research Station, Vedasandur, S. Rly.

TABLE I

Chemical composition of cigar tobacco leaf according to position on the stalk (1952-1953 and 1953-1954.)

Leaf position from bottom	Percentage composition on oven dry, sand and silica-free basis									
	Ash		K_2O		CaO		MgO		Na_2O	
	1	2	1	2	1	2	1	2	1	2
1	21·00	19·95	7·09	5·32	8·83	9·06	2·24	1·99	0·17	0·08
2	23·28	20·07	6·98	5·40	8·30	8·18	2·20	1·72	0·14	0·08
3	18·46	22·94	6·26	5·79	8·35	8·42	2·15	1·85	0·12	0·07
4	20·79	20·60	6·46	6·17	7·76	7·79	1·98	1·67	0·12	0·07
5	23·38	19·33	6·90	4·74	6·92	7·64	1·96	1·61	0·11	0·06
6	18·88	17·60	6·45	4·49	6·84	7·40	2·01	1·54	0·11	0·05
7	21·77	19·27	6·89	4·64	6·64	7·30	1·95	1·48	0·09	0.04
8	20·50	18·44	6·16	5·09	6·54	6·92	1·93	1·52	0·09	0·02
9	20·84	17·73	5·47	5·06	6·38	6·78	1·91	1·42	0·07	0·01
10	19·92	16·28	6·13	4·72	5·95	6·58	1·77	1·41	0·08	0·02
11	18·50	17·12	6·40	4·71	5·64	6·69	1·87	1·44	0·07	0·02
12	17·34	17·13	5·18	4·71	5·74	6·48	1·72	1·38	0·07	0·01
13	17·85	16·00	6·03	4·47	5·04	6·04	1·56	1·36	0·04	0·02
14	17·02	14·99	4·88	4·46	5·19	5·84	1·57	1·37	0·03	0·02
Mean	19·97	18·39	6·23	4·98	6·72	7·22	1·92	1·55	0·09	0·04

1. 1952-1953
2. 1953-1954

TABLE I—contd.

Chemical composition of cigar tobacco leaf according to position on the stalk (1952-1953 and 1953-1954.)

Leaf position from bottom	Percentage composition on oven dry, sand and silica-free basis									
	S		Cl		P_2O_5		N		Nicotine	
	1	2	1	2	1	2	1	2	1	2
1	0·25	0·25	5·40	5·10	0·50	0·28	1·62	1·69	0·54	0·42
2	0·25	0·25	4·87	5·11	0·55	0·27	1·64	1·59	0·60	0·31
3	0·25	0·27	4·79	5·23	0·58	0·29	1·49	1·37	0·46	0·30
4	0·23	0·26	4·41	5·22	0·72	0·29	1·62	1·36	0·50	0·34
5	0·24	0·28	4·70	3·74	0·77	0·37	1·67	1·57	0·61	0·38
6	0·26	0·32	4·41	3·23	0·69	0·54	1·91	1·59	0·75	0·39
7	0·23	0·32	4·44	3·19	0·83	0·68	2·31	1·79	0·86	0·68
8	0·24	0·33	4·16	3·05	0·84	0·77	2·44	1·87	0·93	0·76
9	0·26	0·36	3·89	2·92	0·78	0·76	2·50	1·93	1·07	0·89
10	0·30	0·38	3·89	2·59	0·79	0·82	2·58	1·93	1·33	1·16
11	0·30	0·41	3·67	2·48	0·79	0·85	2·72	2·19	1·40	1·25
12	0·33	0·43	3·34	2·78	0·67	0·83	2·94	2·29	1·58	1·30
13	0·33	0·41	3·36	2·36	0·79	0·83	2·98	2·38	1·34	1·33
14	0·32	0·41	3·60	2·83	0·70	0·83	3·03	2·37	1·37	1·23
Mean	0·27	0·33	4·23	3·56	0·71	0·60	2·25	1·85	0·95	0·77

worked out. The data indicated that the variations in all chemical constituents according to their position on the stalk followed a linear trend, and had a very good fit in each case. The summary of these calculations is given in Table II.

It is observed that the trend in variation in the case of all the constituents in both the years is the same, though the magnitude of variation differed slightly. The overall tendency for the ash content of the leaves is to drop from the bottom to the top of the plant. The topmost four leaves have the lowest ash content. Hanmer *et al.* [1940] had also reported this.

The potassium content of the leaves exhibit a general tendency to decrease from the bottom to the top of the plant. Darkis *et al.* [1936] and Askew *et al.* [1947] observed a similar tendency in the case of flue-cured tobacco. Bowman and Nicholas [1953], however, found that the potassium content decreased regularly from the bottom to the middle of the plant and then exhibited a slight tendency to increase in the upper leaves.

The calcium and magnesium content of the leaves decreases from the bottom to the top of the plant. The highest amounts accumulate in the lowest leaves and the topmost leaves contain about 35-40 per cent less of calcium and about 30 per cent less of magnesium than the bottommost leaves. Hanmer *et al.* [1940] and Askew *et al.* [1947] have reported that the calcium and magnesium content of the leaves decreased from bottom to top in two strains of Connecticut cigar tobacco and flue-cured tobacco respectively. Darkis *et al.* [1936] and Bowman and Nicholas [1953] have, however, reported that though the calcium content decreased from the bottom to the top of the plant, magnesium did not manifest any definite trend.

The sodium content of the leaf is very low and decreases from the bottom to the top of the plant. The sodium content of the bottom leaves is four to five times that of the top leaves.

The sulphur content of the leaf tends to increase from the bottom to the top of the plant. The variation is found to be wider in the second year.

The phosphorus content of the bottom leaves is low and it increases progressively in the upper leaves. In the second year, the P_2O_5 content of the upper leaves is about three times that of the bottom leaves. The findings agree with those reported by Bowman and Nicholas [1953].

The chlorine content of the leaf is very high in the bottom leaves and decreases in the upper leaves of the plant, the trend being similar in both the years. This is, of course, not in agreement with the findings of Bowman and Nicholas [1953] who observed that the chlorine content was unaffected by its position on the stalk.

The total nitrogen content increases regularly from the bottom to the top leaves of the plant. Though the trend is the same in both the years, the average nitrogen content of the leaf in the first year is higher than in the second.

The nicotine content of the bottommost leaves is very low. It increases progressively towards the top, the upper leaves accumulating two to three times more nicotine than the bottom leaves.

Table II

Regression equations and the associated standard errors showing the trend in variation of the different chemical constituents according to leaf position

Constituents	1952-53		1953-54		Significant differences in the regression coefficient	S.E. of estimate 1952-53	S.E. of estimate 1953-54
	Regression equation	S.E. of the regression coefficient	Regression equation	S.E. of the regression coefficient			
Ash	y=21·20—0·330x	±0·104	y=21·71—0·443x	±0·0711	No	±1·57	±1·07
K_2O	y=7·17—0·125x	±0·029	y=5·63—0·086x	±0·026	No	±0·440	±0·390
CaO	y=8·83—0·281x	±0·017	y=8·84—0·216x	±0·014	Yes	±0·260	±0·210
MgO	y=2·27—0·048x	±0·004	y=1·87—0·042x	±0·005	No	±0·064	±0·080
Na_2O	y=0·16—0·009x	±0·0007	y=0·08—0·006x	±0·0007	Yes	±0·010	±0·011
S	y=0·22+0·007x	±0·0015	y=0·22+0·015x	±0·001	Yes	±0·022	±0·016
Cl	y=5·27—0·141	±0·012	y=5·34—0·237x	±0·034	Yes	±0·180	±0·510
P_2O_5	y=0·60+0·15x	±0·006	y=0·19+0·055x	±0·006	Yes	±0·09	±0·09
N	y=1·75+0·132x	±0·009	y=1·28+0·076x	±0·010	Yes	±0·15	±0·15
Nicotine	y=0·29+0·088x	+0·009	y=0·07+0·094x	±0·009	No	±0·14	±0·15

'y' is the nutrient content and 'x' the position of the leaf on the stalk from the bottom.

Nitrogen and nicotine accumulate in larger quantities in the growing regions of the plant. Consequently, their concentration will be more in the upper leaves than in the bottom leaves. This tendency of nitrogen and nicotine to accumulate in the upper leaves of the plant had been recognised by all the workers.

It will be observed that the overall tendency is for the basic constituents of the leaf (K_2O, CaO, MgO, Na_2O) to accumulate in the lower leaves of the plant and decrease in the middle and upper leaves, also the constituents of the leaf which go to form proteins and other energy giving substances of the plant viz., N, P_2O_5 and S accumulate in larger quantities in the growing upper leaves of the plant. The good fit of the curves and the trend in variation of the different constituents are graphically presented in Figs. 1 and 2. The data of the second year have been used for the graphs.

It is seen from the data that there is a considerable difference in the average nutrient content of the leaves in the two years of the study. The variation in the leaf composition might be due to the effects of differences in soil, the crop having been raised in two adjacent but different fields, and also seasonal conditions, though to a much larger extent due to the latter. The effect of season, particularly rainfall on the composition of the leaf has been rather well-established.

The meteorological data for the two years of study for various growth phases of the crop [Tejwani, *et al.* 1957] are presented in Table III.

The seasonal features indicate that 1952-53 was a comparatively drier season with less humidity than 1953-54 ; also, the rainfall was not satisfactorily distributed.

During 1952-53, the crop received up to the time of topping a total rainfall of 5·74 inches in 12 rainy days. But most of this was received as a heavy shower of 3·90 inches on a single day in the fifth week after transplanting, when the crop had made very little growth. There were practically no showers during the 'active phase' when the crop growth was phenomenal.

On the other hand, during the 1953-54 season, the rainfall was well distributed throughout the growth period, with 6·88 inches of precipitation in 20 rainy days, from transplanting to topping. The crop also received 3·36 inches of rain in 8 rainy days during the four weeks from '*mummatti*' digging to topping when the production of most of the vegetative parts takes place.

In studying the effect of season on chemical composition, Darkis *et al.* [1937] with flue-cured tobacco, and Bailey *et al.* [1930] and Hanmer *et al.* [1940] with cigar tobacco, observed that the nitrogen and nicotine content of the leaf is higher in seasons of lower rainfall, the increase being especially pronounced in the upper leaves. The data reported in this paper indicate that the average nicotine and nitrogen content of the leaf was 20-25 per cent more in the relatively drier 1952-53-season as compared to those in the more rainy 1953-54-season.

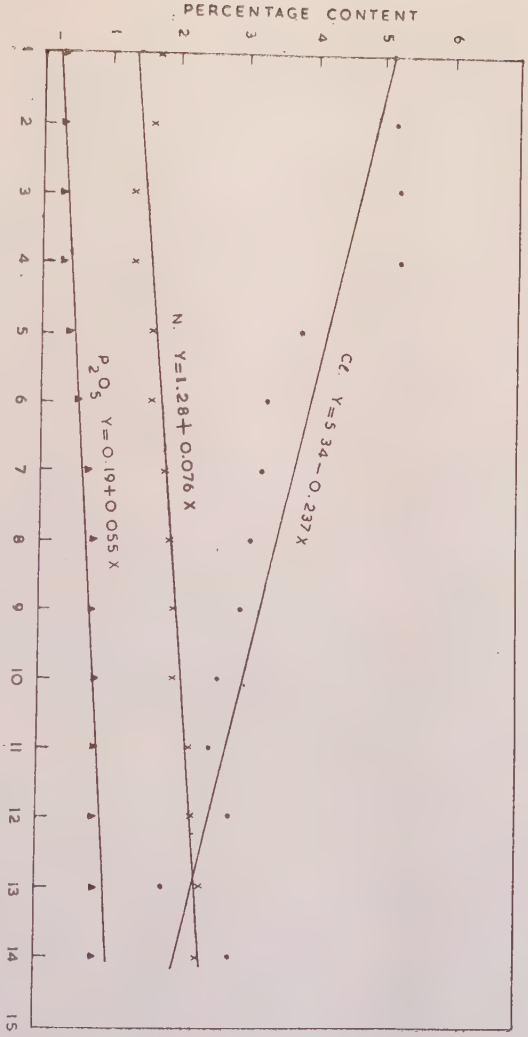


Fig. 1. Chart showing different chemical compositions of the tobacco leaf influenced by its positions on the stalk.

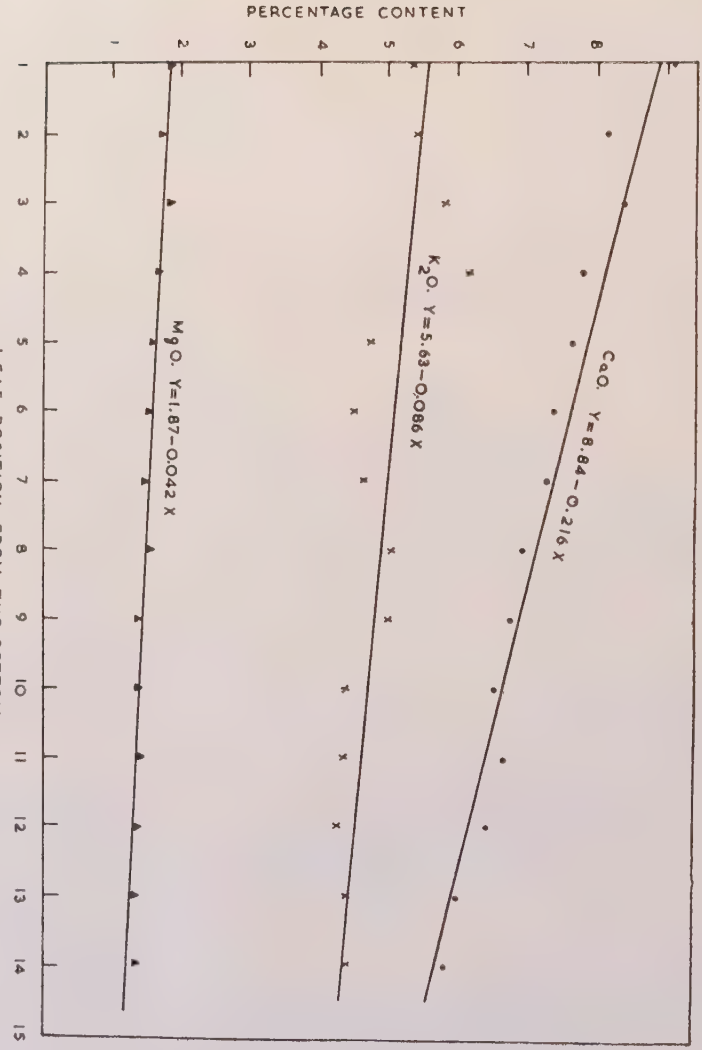


Fig. 2. Chart showing variations in different chemical constituents according to tobacco leaf position on the stalk.

TABLE III

Rainfall, relative humidity and maximum and minimum temperature during the critical growth of cigar tobacco during 1952-53 and 1953-54

Growth period	1952-1953					1953-1954				
	No. of rainy days	Rainfall (inches)	Maximum °F	Minimum °F	R.H. per cent	No. of rainy days	Rainfall (inches)	Maximum °F	Minimum °F	R.H. per cent
I. Establishment phase (transplanting to weeding—3 weeks)	4	0·88	89·2	71·3	79·4	6	2·33	86·7	70·3	91·7
II. Transitional phase (weeding to *mum-matti* digging—3 weeks)	6	4·64	84·2	68·9	84·6	6	1·19	83·3	67·5	91·9
III. Active phase (*mum-matti* digging to topping—4 weeks)	2	0·22	84·0	65·9	84·8	8	3·36	83·7	67·4	92·4
IV. Maturation phase (topping to harvesting—3 weeks)	*Nil*	*Nil*	85·6	62·4	81·2	4	0·94	85·3	66·0	91·8
Total	12	5·74				24	7·82			
Average			85·8	67·1	82·5			84·8	67·8	92·0

Bailey and Anderson [1930] observed that leaves of a drier season contained more chlorine and phosphoric acid. The sulphur content also generally increased, though in some cases, the reverse trend was also observed by them. It will be seen from the data presented here that the chlorine and phosphoric acid content of the leaf is more in drier 1952-53-season, while the sulphur content does not differ appreciably in the two seasons.

Darkis *et al.* [1937], Bailey and Anderson [1930] and Hanmer *et al.* [1940] observed that a wetter season with better distribution of rainfall tended to increase the potassium content and decrease the calcium and magnesium content of the leaf. The data presented exhibit reverse trends to those found by the above workers so far as potassium and calcium are concerned.

Summary

A study of the influence of the position of the leaf on its chemical composition has been made using a typical Indian cigar variety, *Vellavazai*. Analysis of leaf to leaf samples collected over two years showed that the basic constituents of the leaf (CaO, MgO and Na_2O) tended regularly to decrease from bottom to top of the plant. Potassium also exhibited the same tendency though not with equal regularity. Sulphur and phosphoric acid content of the leaf increased from bottom to top. Chlorine exhibited a reverse trend. Nicotine and nitrogen tended to accumulate in larger quantities in the upper leaves of the plant.

In general, the nitrogen, nicotine, chlorine, phosphoric acid, potassium and magnesium contents of the leaf was lower and the calcium content somewhat higher in the wetter season with better distribution of rainfall.

Acknowledgements

The authors are thankful to Dr. N. R. Bhat, Director, Tobacco Research for giving necessary facilities for conducting the above work at Cigar and Cheroot Tobacco Research Station, Vedasandur and also for going through the manuscript critically and suggesting improvements, and to Shri V. N. Murti, Statistician, Central Tobacco Research Institute, Rajahmundry for the statistical interpretation of the data. They are thankful to Dr. B. S. Kadam, former Director, Tobacco Research for giving necessary facilities for work during the early stages of the study.

REFERENCES

Anderson, P. J., Swanback, T. R. and Street, O. E. (1939). Variations in the chemical composition according to their position on the stalk. *Conn. Agric. Expt. Sta. Bull.* **422** : 22—26

Askew, H. P., Block, R. T. J., and Watson, J. (1947). Flue-cured tobacco IV. Effect of position of the plant on the chemical composition of the tobacco leaf. *N. Z. J. Sci. Tech.* **29** : 158—163

Association of Official Agricultural Chemists. (1950). *Official methods of analysis. 7th Edn.*

Bailey, E. M., and Anderson, P. J. (1930). Chemical composition of a poor burning tobacco crop compared with a good burning crop. *Conn. Agric. Expt. Sta. Bull.* **311** : 228—233

Bowman, D. R., and Nicholas, B. C. (1953). Burley tobacco composition according to position on the stalk. *Uni Tenn. Agric. Expt. Sta. Bull.* **229**

Darkis, F. R., Dixon, L. F., Wolf, F. A. and Gross, P. M. (1936). Flue-cured tobacco : correlation between chemical composition and stalk position of tobacco produced under varying weather conditions. *Ind. Eng. Chem.* **28** : 1214—1223

————(1937). Flue-cured tobacco—Chemical composition of tobacco produced on limed and non-limed soils under varying weather conditions *ibid,* **29** : 1030—1039

Garner, W. W., Bacon and C. W. *et al.* (1934). The nitrogen nutrition of tobacco. *U.S.D.A. Tech. Bull.* **414**

Griffith, F. B., and Jeffrey, R. N. (1948). Improved steam distillation apparatus. *Anal. Chem.* **20** : 307—311

Hanmer, H. R., Street, O. E. and Anderson, P. J. (1940). Variation in the chemical composition of cured tobacco leaves according to their position on the stalk. *Conn. Agric. Expt. Sta. Bull.* **433** : 177—186

Piper, C. S. (1944). *Soil and Plant analysis.* The University of Adelaide, Adelaide

Tejwani, K. G., Kurup, C.K.R.K. and Venkataraman, K.V. (In press) Growth studies on and nutrient uptake by cigar tobacco—Part I. Growth characteristics of cigar tobacco. *Indian J. Agric. Sci.*

————(In press.) Growth and quality of cigar tobacco as influenced by its position on the stalk. *Indian J. Agric. Sci.*

PESTS OF CASHEW (*ANACARDIUM OCCIDENTALE*) IN SOUTH INDIA

By E. V. Abraham

[Received for publication on May 15, 1957
Accepted for publication on November 14, 1957]

(With 4 text-figures)

THE cashewnut tree is an important cash and dollar earner of India. It is mainly cultivated in the South, which contributes over 80 per cent of the total production. The present output of nuts is far short of requirements and concentrated efforts are now underway to augment that production. In this context, the protection of the tree and its crop from insect pests becomes a subject of more than common interest.

A scheme for investigation of cashew pests and diseases receiving financial aid from the Indian Council of Agricultural Research was in operation for one year during 1956-57 at the Agricultural College and Research Institute, Coimbatore, and this article gives a review, chiefly of the insect enemies of the tree and its crop, that were met with during an extensive survey of the Madras State (pre-reorganisation), which was undertaken in the cashew growing areas.

Review of literature

The most important record of observations on the insects affecting the cashew is that of Ramakrishna Ayyar [1932, 1940, 1941 and 1942]. Insects such as the tea mosquito—*Helopeltis antonii* S., Cerambycid beetles—*Plocaederus ferrugineus* L., etc., the red banded leaf thrips—*Selenothrips rubrocinctus* G., the flower thrips—*Rhynchothrips raoensis* G., the leaf caterpillar—*Cricula trifenestrata* H., the leaf miner—*Acrocercops syngramma* M., the weevil—*Apion amplum* F., and the scales *Ceroplastes floridensis* C., and *Lecanium latioperculum* G., have been recorded by him as occurring on cashew. Davis [1949] refers to a bug—*Catacanthus* sp. occurring along the West Coast, particularly of Travancore. Madhava Rao [1955] makes mention of the Cerambycid borers as the more important of the pests that he came across.

An intensive survey of cashew growing areas at Mangalore, Nileshwar, Charvattur, Puthur, Vittal and Karkal in South Kanara district and at Taliparamba Perintalmanna, Puthupady, Nilambur, Edpal, etc. in the Malabar district on the West Coast was done. On the East Coast, plantations at Udayarpalayam, Jayamkondan, Chendurai, Adanakottai and Puthukottai in Tiruchirapalli; Nanjikottai

Vallam and Gandharvakottai in Tanjore district; Panruti in South Arcot and Pannayur in Chinglepet were visited for observations on insect pests and study of the extent of damage caused by them. The pests affecting the different parts of the cashew tree are accounted below.

Insects affecting the stem and root

The cashew borer—**Plocaederus ferrugineus L.** (Fig. 1). A medium sized dark brown longicorn beetle (family, Cerambycidae) is one of the most serious pests of cashew. The antennae of the beetle are long, being twice as long as the body in the male, but not longer than the body in the female.

When caught, the beetle makes an indignant squeaking sound by rubbing the prothorax and mesothorax together.

Eggs, which are more or less elliptical, are laid under loose bark, mostly at the basal portion of the trunk and at the exposed portions of the roots. The young white grubs that hatch out bore into the bark and feed on the soft tissues. Some of the grown up grubs bore into the wood also. The grub stage is mainly spent feeding on the thick bark layer. This enables the mechanical removal and destruction of the larvae in the early stages. A full grown grub is stout, fleshy, soft, dull white in colour and is about three inches long. The body tapers slightly from head to tail. The jaws are powerful with which hard wood is burrowed into.

Pupation is below the soil in a calcareous shell, half embedded in an excavation made in the wood. Pupae and beetles have been collected from a depth of about 4 to 6 inches below the surface soil. The exact life history of the beetle is not known, but it extends over some months.

On a tree, grubs in different stages of development are met with at any part of the year indicating thereby the considerable overlapping of generations. The incidence of grubs on the tree in summer from March to May was relatively large and comparatively light in the heavy rainfall period from June to August.

The grubs feed on the subepidermal and phloem cells and the tissues are tunnelled in various irregular directions on the basal trunk and root region. Gum bleeding sets in as a result of the injury. A thick reddish mass of chewed fibre and excreta is thrown behind in the tunnels. When the bark is cut open, the earlier damaged portions are seen as a mass of decayed matter and where the grub is freshly feeding, gummy fluid is noted. Due to the damage caused, the flow of sap is arrested and the tree is weakened. In the later stages, the leaves of the affected trees turn yellow and shed. Fresh foliage is seldom formed. Such trees can easily be detected from a distance. The attack by the beetle is more commonly associated with adult trees of over 15 years in age. The average extent of trees damaged by this pest was found to be about 4 per cent.

The pest appears to be more widespread along the coastal tracts than in the hinterlands. It was more common in South Kanara than in other districts,

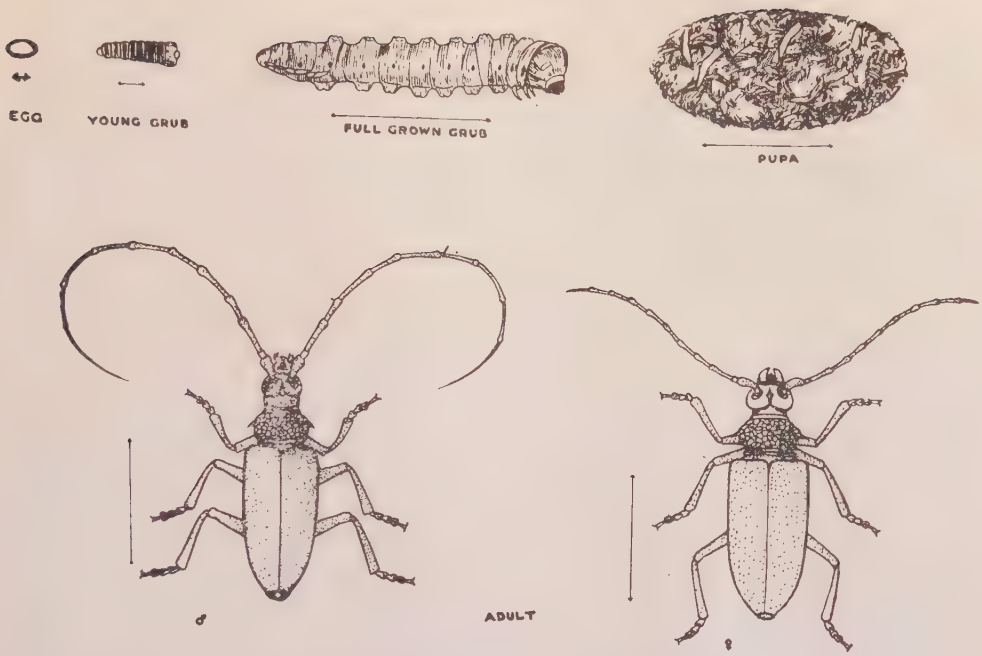


FIG. 1. The cashew borer—*Plocaederus ferrugineus*.

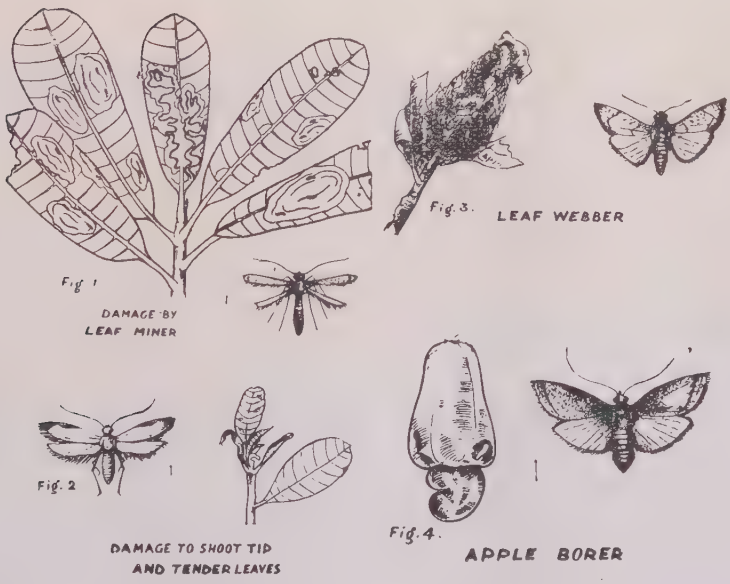


FIG. 2. The leaf webber, shoot borer and apple borer. The plants show the nature of damage done by these pests.

Prionoma atratum G. and *Plocaederus consocius* P. are two other Cerambycid borers that are occasionally met with.

The bark borer—**Indarbela tetraonis Mo.** The caterpillar of this moth makes a small residential hole on the wood and from there it makes inroads through the superficial bark tissues on which it feeds and makes larval galleries. This borer was noted in parts of South Kanara and Tiruchirapalli. The damage is seldom serious.

Insects affecting tender shoots and leaves

The leaf miner—**Acrocercops syngramma M.** [Fig. 2(1)]. This is a major pest appearing during the occurrence of new flush on the trees. The small pale white caterpillar of this tiny silvery grey moth mines into the tender leaves. When full grown, it turns reddish brown and is about $\frac{1}{4}$ inch long. It makes its way out of the leaf tissues and falls into the ground and pupates. The larval stage lasts over nearly two weeks. Under laboratory conditions without soil to pupate in, the caterpillars pupate on the leaf surface, mostly at the midrib region, making a thin membraneous protective covering over it. The pupal stage lasts from 7 to 9 days.

The injury consists of the tortuous markings made on the fresh leaves. Maximum 8 caterpillars were noted on a single leaf. The thin epidermal peel swells up in the mined areas (as if bloated by pumping air inside) after a certain stage when several mined portions merge due to the internal feeding of tissues by the caterpillar. Such areas appear as whitish blistered patches on the leaf surface. On the older leaves, the damage manifests itself as big holes on the leaf surface due to the drying and crumbling of the mined area.

Young plants generally suffer more, due to the pest. The damage was generally worse in the West Coast tracts. On an average, about 26 per cent of leaves on a tree are affected by the pest.

The leaf eating caterpillar—**Cricula trifenestrata H.** This belongs to the family, *Saturnidae* and is a sporadic pest of cashew capable of causing extensive defoliation of the trees. The caterpillar is clothed with poisonous spines and hence it is dangerous to handle. A full grown caterpillar is stout and about 2 inches long. It has sharply defined segments and is of dark brown colour. There is a reddish white stripe along the side. It pupates inside a cocoon made of a loose network of golden silk. The cocoons are spun amongst leaves and twigs in masses. The adult is a reddish brown moth with three clear spots on the wings.

It is recorded as a serious pest of mango in Bengal and Burma [Lefroy 1909]. As seen from the named collections of the Entomology section, Coimbatore, it has been collected from mango in Malabar in 1929. The pest has been subsequently noted in a severe form on cashew in certain years. The author, however, came across only a few caterpillars and pupae in parts of the West Coast. But some orchardists reported of a heavy outbreak of the pest in the previous year. The pest occurs on Terminalia, *Careya arborea* and other trees.

The caterpillar of *Phycita dentilinella* H. parasitises this at the pupal stage (*Proc. IInd Ento. Meet.* 1917).

Caterpillar damaging shoot tip—**Chelaria haligramma M.** [Fig. 2 (2)]. The tiny, yellowish or greenish brown, briskly moving caterpillar of this moth damages fresh shoot tips at the time of new flush. The full grown caterpillar is about ½ inch long. Pupation takes place inside the folded leaves or small bore holes made on the shoot tip or floral branches. The pupa is of yellowish red colour and the pupal stage was found to last for 7 to 8 days. The adult is a tiny dark moth. It occurs on mango also.

Tender leaves are damaged mostly at the bud stage and on a shoot tip three to four caterpillars have been noted. The emerging leaves are folded and the caterpillar remains inside and feeds on them. It occasionally bores into the tender shoot tip to a length of about one inch. Due to the injury, the growing shoot tip becomes stunted and sometimes gets scorched up. An average of 26·5 per cent of tender shoots were seen affected in parts of South Kanara and Tiruchirapalli. A severe damage of inflorescence was noted at Chendurai in Tiruchirapalli district.

The leaf webber—**Macalla sp.** [Fig. 2 (3)]. The apical leaves of fresh shoots are webbed together and the caterpillar feeds on them. The green matter of the tender shoot is also scraped to some extent. The caterpillar makes galleries with the chewed material and castings and rests inside. Young specimens are greenish brown in colour. The full grown caterpillar is about 1¼ inches long. It is dark brown dorsally and greenish ventrally. Laterally, there is a yellow longitudinal band. It pupates inside the larval galleries. The pupa is of dark colour. The pupal stage lasts for 10 to 14 days. The adult is a medium sized dark brown moth.

The pest was observed to damage young plants during summer.

The caterpillar is often parasitised by a braconid (to be identified).

Defoliating caterpillar—**Metanastria hyrtaca C.** The hairy caterpillars of this Lasiocampid moth were noted causing serious damage on isolated trees at Coimbatore by defoliating the branches. During day time, they rest in groups on the basal portion of the tree trunks. A full grown specimen is about 2½ inches long.

The caterpillar is commonly noted on *babul* (*Acacia arabica*) and *parijath* (*Nyctanthus abortristis*).

The slug caterpillar—**Parasa lepida Cr.** This Limacodid caterpillar has been noted to assume severity on isolated plants in parts of Coimbatore.

The adult moth lays eggs in groups on the undersurface of the leaves. The hatching caterpillars feed gregariously in the early stages. The green leafy matter is scraped and eaten, leaving behind the veins. As the caterpillars grow, they scatter themselves on the tree. The caterpillar is bright green in colour. It is armed with poisonous spines and hence dangerous to handle. It pupates on the stem. The pupal case is also covered over with poisonous hairs. The life cycle lasts for about 10 weeks. [Anantanarayanan and Abraham, 1955.]

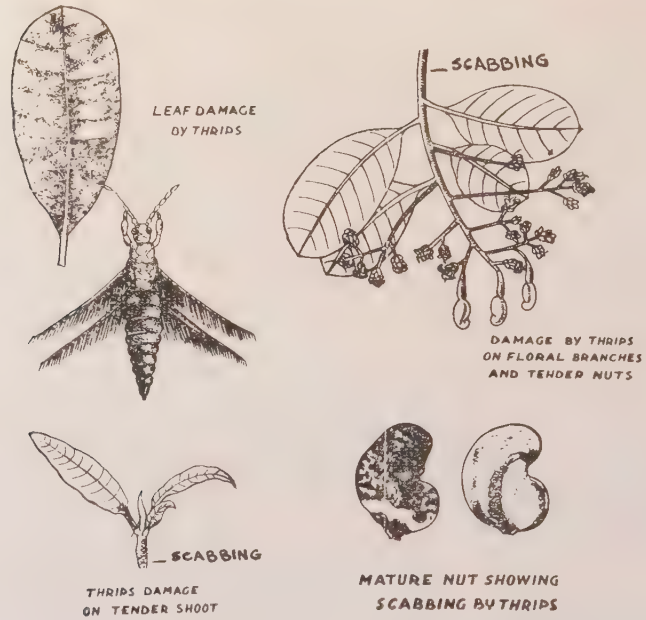


FIG. 3. The Leaf Thrip and the nature of damage it does.

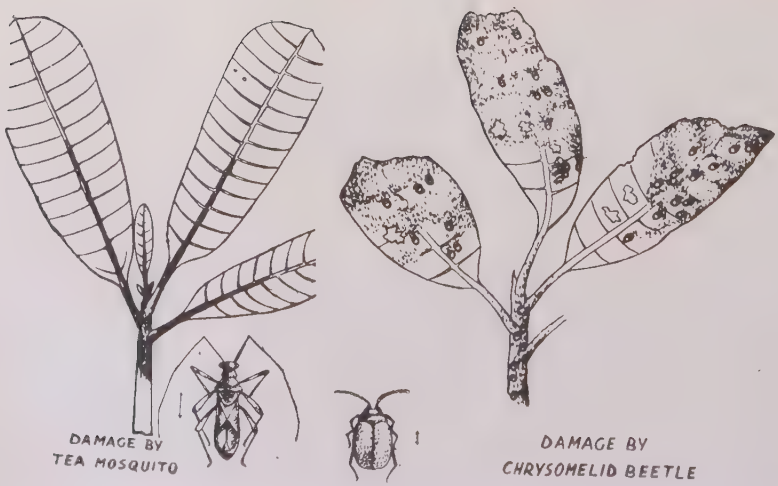


FIG. 4. The Tea Mosquito and Chrysomelid beetle. The two twigs show the damage done by them.

This is a polyphagous insect and has been recorded on castor, mango, pomegranate, citrus, cluster beans, rose, etc.

The looper—**Oenospila flavi uscata W.** Caterpillars of this medium sized Geometrid moth with greenish wings have been noted feeding on tender leaves. The moth lays whitish round eggs singly on the leaf edges. The eggs hatch out in about 5 days. The hatching caterpillar is of a reddish tinge and feeds along the leaf edges. It becomes full grown in about 15 days and attains a length of 1 inch. When full grown, its colour becomes greenish. Pupation takes place inside leaf folds. The pupa is pale red and is attached to the leaf surface by means of a silken thread at the posterior end. The pupal stage lasts for about 10 days. The life cycle occupies about 30 days as observed in the case of three specimens reared in the laboratory.

Although the insect affects young leaves, it is generally a minor pest on cashew.

Stray specimens of the leaf roller—*Sylepta aurantiacallis* F., a small Eucosmid caterpillar—*Argyroploce tonsoria* M. boring into shoots, and the Tassar silk moth—*Antherea paphia* B. have also been collected from cashew.

Thrips

The leaf thrips—**Selenothrips rubrocinctus G., Rhipiphorothrips cruentatus H. and Retithrips syriacus M.** (Fig. 3). Damage by leaf thrips is generally severe on young plants. Due to the sucking and lacerating activity of these creatures, the leaves become pale brown and slightly crinkled. Old as well as young leaves show groups of adults and nymphs during periods of heavy outbreak. The plants become stunted in growth.

Selenothrips and *Rhipiphorothrips* are the more serious and common. The nymphs of *Selenothrips* are easily distinguished by the greenish yellow colour and red band across the first and last abdominal segments.

While the insects were commonly noted on young plants in the different tracts, even older trees were badly affected in Chinglepet district. The trees in the shady areas were found to suffer more and the foliage presented a dried up spectacle.

The insects were observed in a pest form during the hot months of March to May and subsided with the onset of the monsoon.

Selenothrips is occasionally seen on the country almond (*Terminalia catappa*). It is a notorious pest of cacao in different tropical areas. *Rhipiphorothrips* occurs on roses, grape vine, etc. This is the first record of occurrence of *Rhipiphorothrips* and *Retithrips* on cashew.

The tea mosquito—**Helopeltis antonii S.** (Fig. 4). This reddish brown active Capsid bug is one of the most serious pests of cashew. The adult has a peculiar knobbed process projecting from the dorsal side of the thorax. The adult was observed to thrust the eggs into the tender tissues. Up to 500 eggs are laid by a single female. The nymphs are soft ant-like creatures moving about slowly on the tender twigs and leaves.

Adults and nymphs suck up the sap by puncturing the tender plant parts such as shoots, leaves, floral branches, thalamus, apple and nuts. The punctured shoots turn dark and dry up, ordinarily, to a short length. Generally, fresh shoots sprout from below the dried up portion, but such sprouts are also attacked in turn by the bug. When the damage is severe, it results in the drying up of young branches and even the death of the plant if it is young. The midribs of the leaves also turn dark due to the puncturing and on the tender leaf surface numerous dark brown spots are formed.

When the floral branches are punctured, it results in the fading of flowers. As a result of punctures made on apples and nuts, more or less circular depressed water soaked spots are formed which gradually spread concentrically. Such spots turn dark later and the nuts fade and fall. The bug is suspected to infect some virus into the plant tissues [Ramakrishna Ayyar, 1942].

Up to 15 per cent of tender nuts were seen affected by the bug at Adanakottai during April 1956. The extent of damage to tender shoots averages to 25 per cent. The bug was more in evidence in the west coast areas than on the east coast, the reason being probably the abundance of wild vegetation on the west coast for their harbouring.

It is a well known pest of tea and occurs on mahogany, neem, cacao, cinchona and annatto [Fletcher, 1914]. It is reported to be a pest on guava also. It occurs on apple and grape vine fruits in Mysore [Puttarudriah and Appanna, 1955].

Coccids

The mealy bug, *Planococcus lilacinus* C. and the wax scale, *Ceroplastes floridensis* C. were in evidence in small numbers on tender shoots. A mild incidence of a scale (*Diaspis* sp.) infesting the leaves was evident in parts of Tanjore and Coimbatore. The lady bird beetle, *Chilocorus nigritus* F. has been noted preying on this scale. The giant scale, *Monophlebus* sp., occurs in stray numbers on tender shoots.

A Chrysomelid beetle (Fig. 4)

A small red Chrysomelid beetle *Monolepta longitarsus* J. has been noted for the first time, appearing in numbers during the monsoon months of June to August in parts of South Kanara and Malabar. They rest in numbers on the branches and feed on the tender leaves and even the tender portions of the stem by scraping the green tissues. When disturbed, they fly away quickly and their knocking against the leaves produces a characteristic sound like the one experienced when sand particles are thrown against the leaves.

Weevils

The leaf twisting weevil of mango, viz. *Apoderus tranquebaricus* F. was in common occurrence at the time of new flush. The beetle folds the leaves along the midrib, deposits its oval orange coloured eggs on the leaf tip and twists the leaf into a compact roll. The yellow grubs that hatch out grow by feeding on the rolled up leaf tissues.

The damage caused by the weevil is of a light nature only.

Mylloceyus discolor B. Mylloceyus viridanus F. and Amblyrhinus poricollis B. These polyphagous weevils are often seen feeding on fresh leaves of young plants. They are of a minor status on cashew.

Ants

The red ant, *Oecophylla smaragdina* F. is a common source of nuisance to cashew orchardists. Besides nursing on aphids, scales and mealy bugs, this ant aids the spread of these insects from plant to plant.

A *Camponotus* sp. of ant visits young plants and bites tender leaves. Black spots are formed in course of time at the injured region and the leaves put on a diseased appearance.

Insects affecting flowers and fruits

As already dealt with above, the bug *Helopeltis antonii* S. causes fading of inflorescence branches and consequent withering of flowers to some extent. In isolated areas, the nuts were also found affected.

The caterpillar, *Chelaria haligramma* M. (already dealt with) was noted to damage up to 60 per cent of the inflorescence at Chendurai in Tiruchirapalli. The caterpillar bores into flower buds and eats the contents. The inflorescence branches are also partially eaten and are bored to a small extent. Due to the injury, gum exudes from the floral branches and the inflorescence presents a sickly appearance. The development of the inflorescence is arrested and eventually the inflorescence gets dried up.

Flower thrips **Fig. 3.**

Rhynchothrips raoensis G. and a yellow thrips (unidentified) have been noted on the inflorescence and tender leaves. The latter was more commonly seen in all tracts during the flowering season. They have been observed causing scabs on the floral branches, apples and nuts in certain tracts. They infest tender shoots too. The scabbed areas appear as brown patches due to the formation of corky layers. Stray cases of heavy occurrence on isolated trees causing malformation of nuts have been noted.

The mealy bug—*Ferrisiana virgata* C. was noted infesting the inflorescence in a mild form. Isolated cases of heavy occurrence were also observed. Heavy populations cause the shedding of flowers and drying up of the inflorescence.

A soft scale (*Coccus* sp.) occasionally feeds on tender shoots and nuts.

The aphid—**Toxoptera odinae** *Vdg.* This occurs on the inflorescence branches and tender shoots. Heavy infestation can cause flower shedding to some extent.

This is occasionally a pest on mango inflorescence also.

The apple borer, **Nephopteryx sp.** Fig. 2. A pinkish dark, active caterpillar boring into tender apples and sometimes into the tender nuts also was commonly met with in parts of Tiruchirapalli. The caterpillar, when full grown, measures about an inch long. Pupation takes place inside the soil or inside excreta and chewed materials. The pupa is reddish brown in colour. The pupal stage was found to last for 8 to 10 days. The adult is a medium sized moth with dark fore wings and pale dark hind wings.

The caterpillar of a Tortricid moth occasionally feeds on tender nuts. It webs together dried up flowers and shelters inside. When full grown, the caterpillar is greenish in colour and $1\frac{1}{4}$ inches long. The pupal period lasted for 6 to 7 days in the laboratory.

The adult is a medium sized moth with brownish upper wings and bright yellow hind wings.

A small pinkish caterpillar of a tiny brown moth (to be identified) has also been noted boring into ripe apple at the joint between the apple and nut.

The hairy caterpillar—**Euproctis scintillans W.** The caterpillars of this Lymantrid moth occasionally feed in groups on the inflorescence and tender nuts of cashew. They scrape the green tissues on the inflorescence branches and feed on the shell of the nut in the tender green stage. Occasionally, the leaves are also scraped and eaten. The adult has yellowish wings. It lays eggs in batches, covered over with hairs, on the leaf surface. In the young stage, the caterpillars are gregarious in habit and as they grow, they disperse. Pupation generally takes place in thin silken and hairy cocoons in leaf folds. The pupal stage lasted from 7 to 9 days in the laboratory.

The insect occurs also on mango and other plants.

The Chrysomelid beetle, *Monolepta orientalis* J. has been noted feeding on flower petals in parts of Tanjore district.

The black ant, *Sima allaborens* W. was found living in colonies inside tunnel seen on inflorescence branches. The exact role played by this remains to be investigated.

Non-insect pests

Rats and squirrels destory seedlings by eating the cotyledons immediately after germination. Bats and monkeys remove ripe apples from the trees and discard the nuts after eating the apple. The discarded nuts are often damaged by their biting on the shell while eating the apple.

Stored product pests

The red grain beetle—*Triboleum castaneum* M. the saw toothed beetle, *Oryzaephilus surinamensis* L. the red legged ham beetle—*Necrobia rufipes* F. the cadelle beetle—*Tenebroides mauritanicus* L. the fig moth—*Ephestia cautella* W. the Indian

meal moth—*Plodia interpunctella* H., etc. have been noted damaging cashew kernels in storage in the factories that were inspected. The house rat, *Rattus rattus rufescens* G. cuts open stored nuts and eats the kernels.

Control of Pests

Research on the evolution of specific control measures for the various pests has to be pursued on an intensified scale. Some broad lines of control are indicated below.

The cashew borer, *Plocaederus ferrugineus* L. is a difficult pest to be controlled. Mechanical removal of eggs, grubs and pupae at the early stage of infestation and a drenching spray on the basal trunk and at the root region with BHC 0·1 per cent (1 lb. of 50 per cent wettable powder in 6½ gallons) was found to give some relief. Bored holes may be syringed with the chemical. Badly affected trees have to be cut and burnt together with the live stages of the pest.

Thrips can be controlled by sprays of BHC 0·05 per cent (1 lb. in 13 gallons) or Parathion 0·025 per cent (1 oz. of Folidol E. 605 in 12½ gallons or 1 oz. of Ekatox 20 in 5 gallons).

The leaf miner being an internal feeder is also difficult to control. Spraying with Parathion 0·025 per cent synchronising with the formation of new flush may be resorted to for tackling the pest.

DDT 0·1 per cent spray (1 lb. of 50 per cent DDT wettable powder in 50 gallons) is a known remedy against *Helopeltis antonii* S. on tea.

For coccids in general, Farathion 0·025 per cent spray has been found to be most effective and as such its use is recommended.

BHC or DDT will usually suffice for soft bodied caterpillars. BHC 0·05 per cent spray is spectacularly effective against *Parasa lepida* Cr. and the red ant, *Oecophylla smaragdina* F.

F.O.R.S. (1 lb. in 10 gallons) or Parathion 0·025 per cent is effective against hairy caterpillars. Young stages are susceptible to BHC 10 per cent dust or BHC 0·1 per cent spray.

Mechanical method of collection and destruction is feasible when the caterpillars of *Metanastria hyrtaca* C. rest in groups on tree trunks during day time. This is possible in the case of *Parasa lepida* Cr. and *Euproctis* sp. of caterpillars in the early stages when the larvae are gregarious in habit.

Fumigation with methyl bromide at 1 lb./1000 c. ft. of space is an effective measure for control of insect pests affecting kernels in storage.

While extending cashew area in the country, seedling or layers may be carefully examined for pests and diseases and affected materials should either be eliminated or suitable remedial measures adopted in order that the spread of the pest to new localities may be averted.

Discussion

Of the 40 insects mentioned in this paper as occurring on the cashew tree, a dozen were already recorded by earlier workers. The rest have been recorded for the first time on cashew as far as can be seen from available literature on the subject. Neither the weevil, *Apion amplum* F. nor the bug, *Catacanthus* sp. recorded as serious pests by Ramakrishna Ayyar [1942] and Davis [1949] respectively, was evident on the trees in the different tracts surveyed.

Certain aspects like large scale blossom withering and shoot drying of cashew have to be investigated further. A generally mild incidence of mealy bugs, aphids, flower thrips and the tea mosquito bug was found in association with blossom withering in some tracts. Their population was, however, too meagre to be considered as responsible for the widespread occurrence of the feature as experienced in 1956. The caterpillar, *Chelaria haligramma* M. was noted boring into flower buds and floral branches at the very tender stage, causing an eventual drying up of the inflorescence in a few places in Tiruchirapalli during 1957.

The tea mosquito bug, *Helopeltis antonii* S. was found in association with shoot drying in some places.

Some fungus diseases, weather factors, shallow soil conditions, etc., are also involved in these troubles on cashew.

In this paper, only a brief account of the different pests and nature of damage has been furnished. Detailed studies are necessary for determining their exact life histories and for evolving specific control measures.

Summary and conclusions

As many as 40 insects occurring on the cashew tree, a few stored product pests and some non-insect pests have been dealt with in this paper. Of the different insect pests affecting the cashew tree, the root and stem borer—*Plocaederus ferrugineus* L. the leaf thrips—*Selenothrips rubrocinctus* G. and *Rhipiphorothrips cruentatus* H. the leaf miner—*Acrocercops syngramma* M. the tea mosquito—*Helopeltis antonii* S. the leaf caterpillar—*Cricula trifenestrata* H. and the caterpillar—*Chelaria haligramma* M. are the more important and major ones.

The leaf webber—*Macalla* sp., the flower thrips—*Rhynchothrips raoensis* G. and an unidentified yellow thrip, the apple and nut borer—*Nephopteryx sp.* M. the Chrysomelid beetle feeding on leaves, the hairy caterpillar—*Metanastria hyrtaca* C. the mealy bug,—*Ferrisiana virgata* C. and the aphid—*Toxoptera odinae* Vdg. are generally minor pests, but may assume serious proportions occasionally.

Other pests like scale insects, the Geometrid caterpillar, *Oenospila flavifuscata* W. leaf weevils, etc., and non-insect pests seem to be of a minor status only.

Inflorescence drying and shoot drying are serious troubles on cashew. Some insects, fungi, soil conditions and other causes are involved in these troubles.

BHC 0·1 per cent spray and syringing for the cashew borer, BHC 0·05 per cent spray or Parathion 0·025 per cent for thrips, parathion 0·025 per cent for leaf miner and mealy bugs and DDT 0·1 per cent for the tea mosquito are some of the important control measures to be adopted.

Acknowledgment

The author is thankful to Shri M. Basheer, Govt. Entomologist, Coimbatore, and Shri U. Narasinga Rao, Horticulturist and Professor of Horticulture, Coimbatore for their guidance in the investigations and help in writing the article. He also thanks Shri K. P. Anantanarayanan, retired Government Entomologist, who guided the early part of the investigations.

References

Anantanarayanan, K. P. and Abraham, E. V. (1955). The Castor slug caterpillar, *Parasa lepida* Cram. and its control *J. Bombay Natr. Hist. Soc.* **53**, No. 2

Anonymous (1917). *Proc. IInd Ent. Meet.* Pusa, 217-218

Davis, T. A. (1949). An unrecorded pest of the cashew tree (*Anacardium occidentale*) in South India. *Curr. sci.* **18**, 133

Fletcher, T. B. (1914). *Some South Indian Insects.* Government Press, Madras

Lefroy, H. M. (1909). *The Indian Insect Life.* Thacker, Spink & Co., Calcutta

Madhava Rao, V. N. (1955). Cashewnut cultivation in South India. *I. C. A. R. Farm Bull.* No. **9**, 18

Puttarudriah, M. and Appanna, M. (1955). Two new hosts of *Helopeltis antonii* S. in Mysore. *Indian J. Ent.* **17**, 391-392

Ramakrishna Ayyar, T. V. (1932). Annotated list of the insects affecting the important cultivated plants in South India. *Agric. Dep. Madras.* Bull. No. 27, 51-52

——————— (1940). *Hand book of Economic Entomology for South India.* Govt. Press, Madras

——————— (1941). Insect Associates of the cashew plant in South India. *Proc. 28th Indian Sci. Congr.* 208

——————— (1942). Insect enemies of the cashewnut plant (*Anacardium occidentale*) in South India. *Madras Agric. J.* **30**, 223-226.

THE BIOLOGICAL CONTROL OF COCCID PEST IN SOUTH INDIA BY THE USE OF THE BEETLE, *CRYPTOLAEMUS MONTROUZIERI* MULS.

By V. Tirumala Rao and A. Leela David, Agricultural College and Research Institute, Coimbatore (Madras State)

[Received for publication on October 27, 1953
Accepted for publication on December 18, 1956]

(With 6 text-figures)

OF the scale insects and mealy bugs which infest different plants all over the world, only a few cause sufficiently serious injury to economically important plants. Because of the presence of a hard test as an impervious shield over their bodies in the former and the coating of wax in the latter, it is difficult to control them by insecticides. Even when effective chemicals are available, the usually extensive host range of the pests affords them facilities for taking shelter on wild hosts while such measures are instituted and reinfesting the fields later. Therefore, there has always been a search for checking their spread by the use of their natural enemies. Among these the Australian predatory ladybird beetle, *Cryptolaemus montrouzieri* Muls., has been employed in a number of instances in various countries. Trials were undertaken in the Entomology laboratory of the Agricultural College and Research Institute, Coimbatore, on this beetle from 1952 onwards for the control of some of the important coccid pests of South India. The results are set forth in this article.

Review of literature

Considerable literature has accumulated on the trials made with the Australian beetle, *Cryptolaemus montrouzieri* Muls. Hall's [1927] experience has been that the beetle effectively controls a number of coccids in Egypt when introduced in sufficient numbers. Smith and Armitage [1931] succeeded in keeping under check the destructive citrophilus mealy bug, *Pseudococcus gahani* Green and *P. citri* Risso, in California by large scale multiplication of the beetle and liberation in the affected gardens.

Biology and habits of the beetle

The beetles were reared successfully in the laboratory on a number of coccids and were found to breed all through the year in Coimbatore. The life cycle varied from 24 to 28 days, the egg stage being 3-4 days, larval 14-16 days and pupal 7-8 days.

There was no marked difference in the life cycle in the summer, monsoon and cold weather seasons. The temperature and humidity during these seasons were as follows :

	Max. temp.		Min. temp.		Humidity	
	Range	Average	Range	Average	Range	Average
Summer season—					(Per cent)	(Per cent)
April to June 1953	89·9°—102·3°F	93·2°F	61·8°—89·6°F	72·7°F	50—94	82·8
Monsoon season—						
July to Nov. 1952	76·6°—92·9°F	86·9°F	56·6°—76·0°F	73·8°F	65—100	86·6
Cold season—						
Dec. 1952 to Mar. 1953	79·0°—93·0°F	90·0°F	57·4°—73·9°F	67·8°F	63—97	79·4

A temperature range of 75°F to 85°F, as noted by Hall [1927] was favourable for the rearing of the beetles which did not survive at higher temperatures. The breeding of these undertaken at Bapatla from November 1953 had to be abandoned in April 1954 owing to extensive mortality when the temperature rose up to 100°F.

The beetles copulate 8-11 days after emergence and commence oviposition a day or two later. The total period of oviposition extended up to 93 days in one case, with an average of 75 days. The number of eggs laid in a day averaged 14 with a maximum of 23. The total number of eggs laid during the entire life period of a beetle came up to 207. The longevity of the male was on an average 52·5 days and reached a maximum of 65 days while that of the female was 80·2 and 105 respectively.

Laboratory propagation of the beetle

For large scale propagation of this beetle, *Pseudococcus citri* Risso, raised on potato sprouts has been in use in California and other countries. David *et al.* [1953] found the beetles breeding extensively on the prickly pear cochineal, *Dactylopius tomentosus* Lam. Since this cactus and the cochineal were available around Coimbatore and the chopped bits of the cochineal bearing cactus preserved well for about a week, this cochineal was chosen for the breeding of the beetle in the laboratory.

The multiplication in bulk of the beetle was carried on by placing bits of cochineal-infested cactus in glass cages (Fig. 3) and letting the beetles to feed on them. The beetles were removed after 3 days and the material kept in open rectangular trays (Fig. 4a and 4b). The grubs which hatched out moved about actively and preferred feeding on the egg masses. When the cactus began to show signs of decaying they were removed and fresh material used. The grubs required 3 to 4 egg masses during their life time. After about 10 days the grubs were transferred to deeper trays and covered over with a wire-gauze lid. At the time of pupation the grubs crawled about for considerable distances but when confined in the

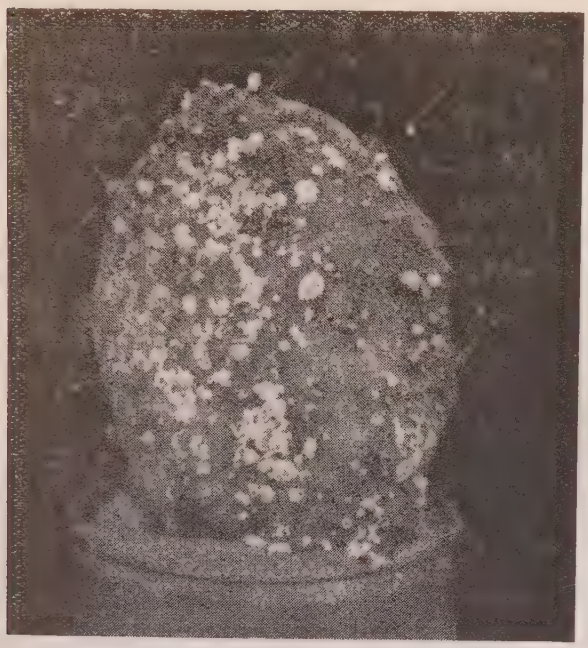


FIG. 1. Cryptolaemus grubs among the cochineal on prickly pear.

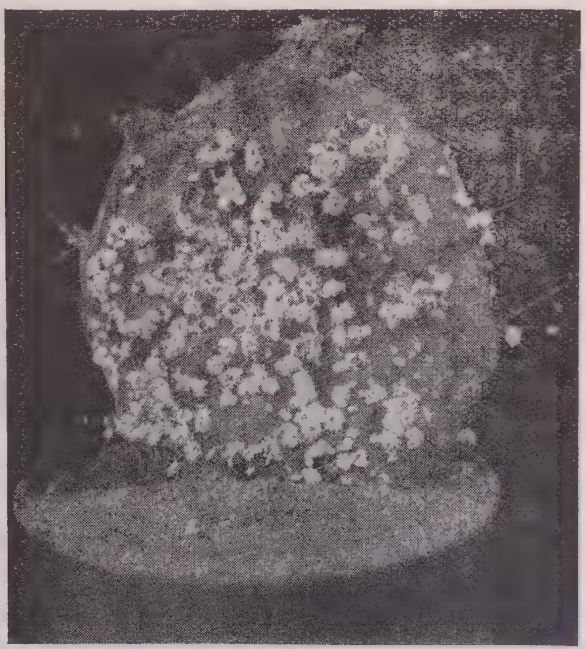


FIG. 2. Cryptolaemus pupae on cochineal-infested prickly pear.

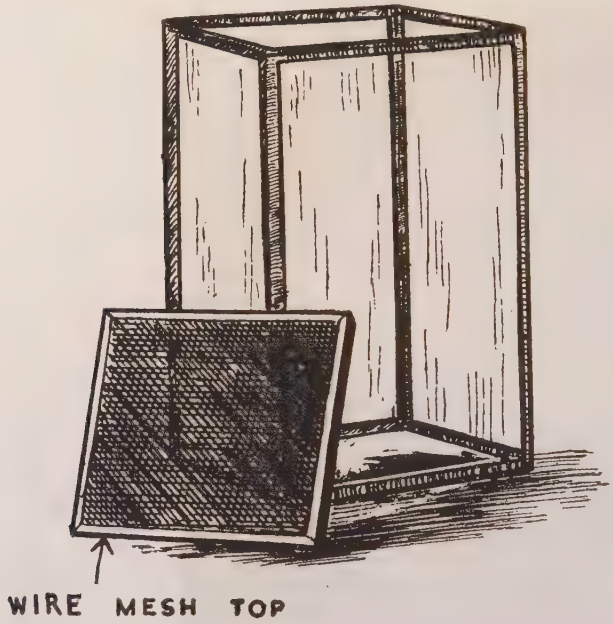


FIG. 3. Breeding cage with glass sides.

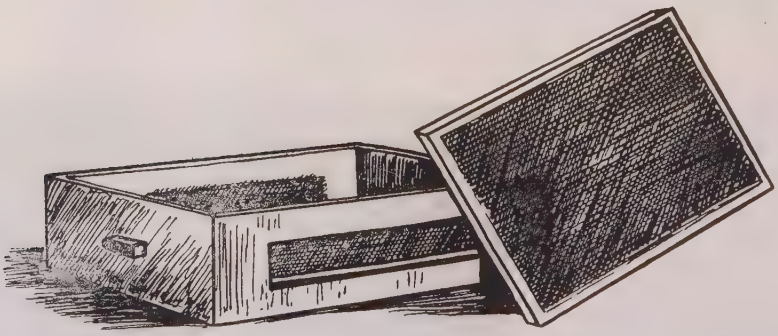


FIG. 4a. Rearing tray with wire-mesh sides and lid.

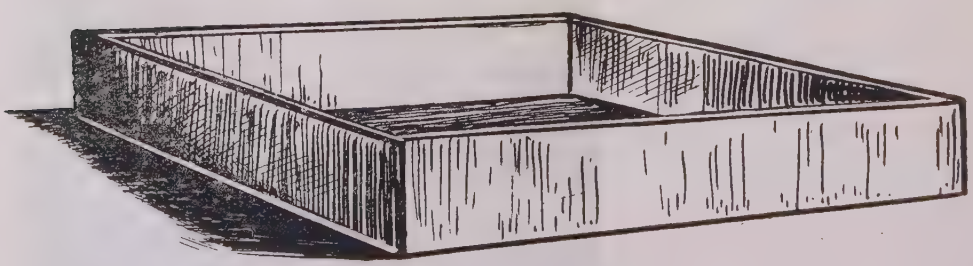


FIG. 4b. Rearing tray.

trays they pupated mainly on the cactus itself. After emergence the beetles began feeding on the cochineal. The cactus bits with the cochineal had to be dried during the rainy season in a warm chamber. About two weeks were allowed for the beetles to get mated and then were despatched for liberation in the field. For mailing the beetles through post a wire-gauze cage was found to be the most suitable one (Fig. 5).

Attempts were made to rear the beetle on artificial food made of honey, butter, and white of an egg in the proportion of 1 : 2 : 2 by weight mixed with wheat flour. In one set all the ingredients were mixed and baked and in another all except the wheat flour were baked and mixed with the latter. The beetles preferred the second preparation but the grubs did not feed on either. The beetles fed on this food, however, failed to reproduce.

The rearing of the beetles by this method was quite easy and was attended to by unskilled labourers. In eight months, 22,266 beetles were produced at an estimated cost of Rs. 360 which works out to about 60 beetles per rupee. The peak emergence of 695 beetles was obtained for a day by the middle of March, 1953.

Host preferences of the beetle

Various coccids occurring on crops at Coimbatore were tried to determine the preferences for food by the beetle. It was possible to divide the coccids into three groups.

I. Coccids freely used as food. In this case the beetles could be fed and bred on them in the laboratory and established on coccid colonies in the field :

1. *Dactylopius tomentosus* Lam., on *Opuntia dillenii* and *Nopalea cochinilifera*
2. *D. indicus* Green on *Opuntia monocantha*
3. *Phenacoccus insolitus* Green on brinjal (*Solanum melongena*)
4. *P. magniferae* Green on mango (*Mangifera indica*)
5. *Pseudococcus lilacinus* Chll. on pomegranate (*Punica granatum*) sapota (*Achras sapota*) and *Glyricidia maculata*
6. *P. corymbatus* Green on oranges, lemons, pomeloes, etc. (*Citrus* sp.)
7. *Ferrisiana virgata* (Chll.) on tomato (*Lycopersicum esculentum*) *Antigonon leptopus* and cowpea (*Vigna catiang*)
8. *Pulvinaria maxima* Green on *neem* (*Azadirachta indica*)
9. *P. Psidii Mask.* on sapota (*Achras sapota*), guava (*Psidium guava*), *Erythrina indica*, *Mimusops hexandra* and *Wrightia tinctoria*

II. Coccids taken as food but not favoured for colonisation :

1. *Ripersia* sp., on paddy and sugarcane
2. *Pseudococcus bromeliae* Bouche, on pineapple
3. *Lecanium viride* Green on coffee (*Coffea arabica*)

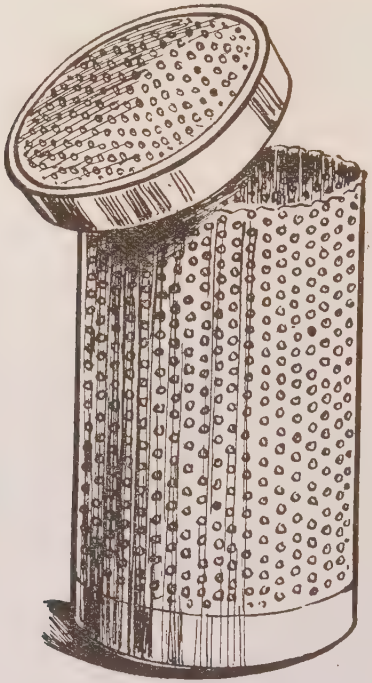


FIG. 5. Transport cage of perforated sheet.

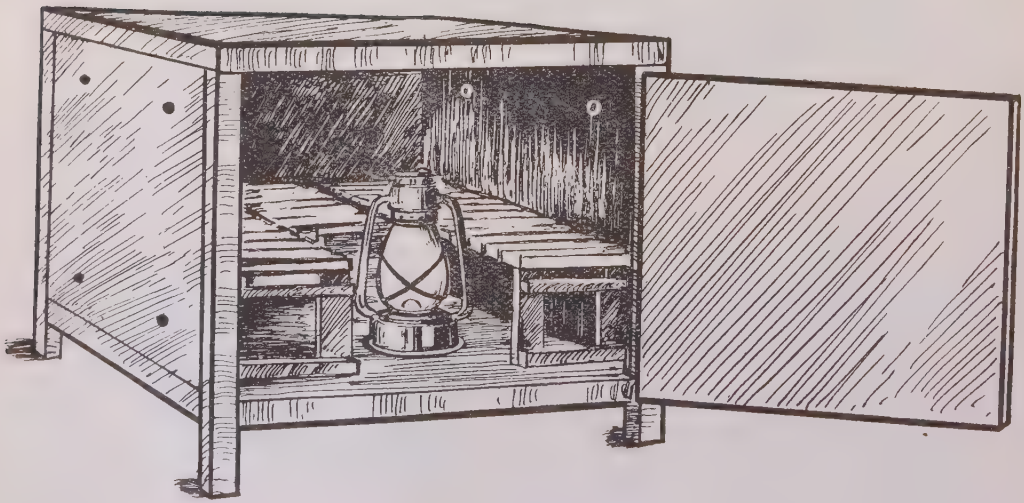


FIG. 6. Warm chamber.

III. Coccids not accepted as food :

1. *Pseudococcus longispinus* Targ. on coconut (*Cocos nucifera*)
2. *Phenacoccus spinosus* Rob. on wild plants
3. *Aonidiella aurantii* Mask. on rose (*Rosa centifolia*)
4. *Parlatoria zizyphus* (Lucas) on citrus sp.
5. *Iceray purchasi* (Mash) on *Acacia* sp.
6. *Anomalacoccus indicus* (Green) on *Acacia arabica*

Trials on the control of some injurious coccids

As the beetles were being bred continuously it was possible to send them for liberation in the field all through the year. However, it was found that they died (due to the heat) during transmission in summer from April to June. Only those which were sent to the hill stations (during this period) survived. In the field the beetles were liberated at the rate of about 500 beetles and 500 grubs per acre and in the case of trees at about 10 of each per tree. The best time for releasing them was the evening as the predator settles down immediately and begins feeding by the next morning. The following observations were made regarding their capacity to control the coccids in the field:

1. *Pulvinaria maxima* **on neem.** In December, 1952, about 100 trees round in Coimbatore were found infested with the scale and the beetles were liberated. By April, 1953, the beetles were breeding in large numbers and the scales dwindling down to insignificance. The beetles had established even as far as half a mile from the site of the original liberation.

2. *Phenacoccus insolitus* **on brinjal.** Beetles and grubs were released in half-acre plots in six places in Krishna and Guntur districts in December, 1952. By the middle of February, 1953, all the mealy bug colonies had been cleared.

3. *Pulvinaria psidii* **on sapota, guava and Mimusop sp.** The colonisation of the beetles resulted in bringing down the infestation in two months.

4. *Pseudococcus corymbatus* **on citrus.** A somewhat severe infestation in Tenali, Guntur District was wiped out by the liberation of the beetles in two months.

Conclusions

Cryptolaemus montrouzieri Muls. was found to be a useful predator which could control a number of coccid pests of crops. Rearing the beetles in the laboratory is quite simple.

Acknowledgements

The authors thank the Government Entomologist, Mysore for sending the first consignment of *Cryptolaemus* beetles ; Shri T. S. Muthukrishnan, Assistant in Entomology for kindly identifying the coccids and Shri M. Gundan and Shri K. P. Krishnan, Fieldmen for help rendered in the course of the work.

REFERENCES

David, Leela A. and Muthukrishnan, T. S. (1953). The prickly pear cochineal : Observations of its natural hosts and enemies in South India. *Indian J. Ent.*, **15**, 219-224

Hall, W. J. (1927). The introduction of *Cryptolaemus montrouzieri* Muls. into Egypt. *Bull-Ent. Res.* **12**, 385

Smith, H. S. and Armitage, H. M. (1931). The biological control of mealy bugs attacking citrus. *Uni. Calif. Coll. Agri. Agri. Expt. St. Calif. Bull.* 509

Smith, H. S. and Compere, H. (1928). The introduction of new insect enemies of citropilus mealy bug from Australia. *J. Econ. Ent.*, **21**, 6-64.

OBSERVATIONS ON THE TERMITES AFFECTING TEA IN NORTH-EAST INDIA AND THEIR CONTROL

By G. M. Das, Senior Entomologist, Tocklai Experimental Station, Assam (Assam)

[Received for publication on October, 29, 1957
Accepted for publication on December 31, 1957]

THE activities of termites affecting tea in north-east India have been on the increase in recent years. The termites that are responsible for damage to tea bushes may be classified into two groups: (1) scavenging termites which generally attack deadand dying tissues and are regarded as secondary pests of tea and (2) live-wood eating termites which attack living tissues of tea bushes and are considered to be primary pests of tea.

The loss of tea crop, as a result of damage by a species that attacks the living tissues of the tea bush on the north bank of the Brahmaputra and in Cachar is considered to be high and unless immediate steps are taken to check the pest, it may sooner or later become a menace to tea-growing in these districts. The consensus of opinion is that deep cultivation practised during the cold weather in the past used to destroy a considerable proportion of the populations of termites, particularly the live-wood eating termite, along with their nests, but this practice was considered to be detrimental to the health of bushes since it damaged a large number of roots and rootlets and also caused erosion of sloping ground, and had, therefore, to be abandoned in favour of surface cheeling. Obviously, cessation of deep hoeing has left this termite undisturbed in the soil, with the consequent increase in its population. Whether the benefits derived from the adoption of surface cheeling outweigh the increased loss incurred from the termite damage is a controversial matter, but there are reasons to believe that periodic light hoeing or forking is advantageous where the live-wood eating termite is concerned. The other cause for the increased activities of this termite as well as the scavenging termites on tea, particularly on old bushes, is the prevalence of dead snags and other dead tissues resulting from branch canker, borer damage, fungal attack, etc.

Scavenger termites

These termites have their nests either in the mounds or below the surface of the soil. They tunnel through the soil to reach the bushes, and attack any dead and dying bark and wood under a cover of earth runs. The common mound-building termite found in the plantation areas is *Odontotermes assamensis* Holm. while those which have their nests in the soil are mainly *Odontotermes parvidens* K. and N. Holm. and *Odontotermes* spp. These termites are widely distributed in north-east India and occur in almost all the tea-growing districts. Dead and dying bark and wood resulting from borer damage, fungal attack, hail damage, sun-scorch, branch-canker,

pruning cuts, etc. are the primary objects of their attention ; in the absence of such tissues the bushes will suffer little. Andrews [1916], however, stated that in the absence of snags, they will attack older hide-bound parts of tea bushes but without any material damage. Hutson [1923] considered that the prevalence of branch cankers had been one of the contributory causes of the marked increase of the scavenging termites in Ceylon.

Having obtained a foothold on the bush the termites work upwards and downwards inside or along the sides of the stems. In fact, they hardly attack any healthy tissues but merely clean out dead, dying and crumbly wood. This is obviously ollowed by further dying of the tissues around the wound, which are eventually removed. Continued removal of such tissues, prevents the wounds from healing up, and results in the formation of cavities in the stems. With increasing damage every year, the cavities and hollows are progressively enlarged. This is aggravated during the rainy season when the tissues around the cavities and hollows in the stems are much decayed, particularly where the rain water is lodged, providing the termites with further material to act upon after the rainy season is over. The branches thus may be completely destroyed, while some are easily broken off.

This process goes on until many of the branches are lost and the bush ultimately succumbs, though this may take several years.

The horizontal or lateral branches which are subjected to sun-scorch too often show cracking of the bark on the upper surface, which may lead to attack by a pathogenic fungus, killing the cambium layer inside and extending downwards [Tunstall and Sarmah, 1947]. The termites remove these dead and diseased tissues, resulting eventually in the formation of irregular cavities. Hutson [1923] believed that in following the advance of a disease, the termites may, however, sometimes go ahead of it.

The excavated and hollowed-out stems are in due course filled up with the earth carried by the termites. The earth has a deleterious effect on the adjoining tissues, which are further decayed during the rains, providing enough material for the termites to extend their activities. Occasionally, however, adventitious roots are put forth from the inner walls of the excavated stems.

The attack is usually confined to the part above ground level but it may, in rare instances, extend down into the roots. Direct attacking of the roots, however, is not common, and can be treated almost invariably to some contributory cause such as root-rot diseases, Cerambycid-borer damage and mechanical-damage through cultivation.

Andrews [1916] described in detail the nature and extent of damage caused by scavenging termites with illustrations.

Live-wood eating termites

Microcerotermes sp. is the only termite that has so far been recorded to be concerned with the direct injury to living tissues of the tea bush. It is prevalent in the North Bank and Cachar districts of Assam where it is considered to be one of the

major problems in tea-growing. It does not confine its attack to dead and dying tissues, but like *Kalotermes* spp. of Ceylon [Hutson, 1923 ; Jepson, 1926] it attacks living tissues of the tea bush. While *Kalotermes* spp. have their nests in tea bushes, *Microcerotermes* sp. has its nest in the soil ; these are very small, situated usually at 3 to 12 inches below ground level.

According to Andrews [1923] the depredation by termites of the group which in Ceylon, from their colonies inside a living tea bush is usually confined to seed-gardens in north-east India, so much so that they can hardly be ranked as a pest of plucking tea. He probably considered the species which attacks healthy tissues or tea bushes in the North Bank and Cachar to be a scavenging termite.

Dead bark and wood resulting from borer damage, fungus damage, cankers, pruning cuts, dead snags and scars are usually used to obtain a foothold in the bushes (under a cover of earth runs) though it is not uncommon to find the termite attacking living bark and wood to gain entrance into the heart-wood. A fine channel is excavated along the heart-wood, and this is progressively enlarged by eating away the surrounding tissues until the stems are more or less hollowed out, often leaving the bare outer covering of a thin layer of wood and the bark.

As in the case of scavenging termite damage, irregular cavities are often excavated, usullay on the upper surfaces of the lateral branches, but hollowed-out stems are common. Excavated cavities are frequently filled up with earthy matter.

Continued depredation of live-wood results in a severe loss of branches, and the ultimate death of the bushes.

There is little difference between the nature of damage caused by *Microcerotermes* and that of scavenging termites. The former being a live-wood eating termite, the destruction of the frame is, however, rapid ; but while many stems are completely hollowed out, there may be occasionally no external indication of the infestation, apart from the mud runs present on the main stem. Hutson [1923] observed that in spite of hollows in the stems caused by *Kalotermes* (*Neotermes*) *usmilitaries*, the bushes continued to flush because the sap wood remained intact and carried on the normal function of the plant. His observations relate to the conditions found in a few instances of *Microcerotermes* attack in its early stage where the outer walls (bark and sap wood) of the stems remain intact, but these hollows sooner or later become exposed at places by further damage or deterioration of the tissues.

Control of termites

Control of termites which build mounds is not difficult at all. DDT, BHC, Aldrin and Dieldrin were found to be highly effective in our trials carried out in the past and have been recommended for their control. The method of application is simple and all that has to be done is to remove the top of the mound and then introduce 5 per cent dust of any of these insecticides at 2 to 8 oz. per mound (depending on its size) through a few holes which have already been enlarged by a stick. This is followed by pouring down two or three bucketful of water, and then covering the

top with soil. The method has been fully described in our advisory publication (*Tea Encyclopaedia Serial* 52/1 under J.3). While the elimination of dead and dying tissues and the covering of exposed wood with a protecting paint would virtually keep the bushes free from the attention of scavenging termites, the main problem is how to control *Microcerotermes*, which attacks the living tissues and is not entirely dependent on dead and dying tissues to get a foothold on the bush. This termite very often attacks healthy tissues to bore into the heart-wood even when dead tissues are available. It is apparent, however, that even in the absence of dead and dying tissues, bushes will always suffer loss from its attack. A series of trials were carried out for the control of live-wood eating termites and the insecticides used were mostly Aldrin and Dieldrin.

Experiments and Methods

The insecticides were applied to the soil as a spray and as a dust and lightly forked down soon after application unless otherwise stated. As a pre-treatment, dead and diseased tissues were removed from the bushes, and cavities and hollows cleansed of earthy matter and termites, as far as possible. Badly damaged branches which were beyond repair were cut out. The cut ends and any exposed wood were covered with a protective paint (Indopaste). The earth-runs on the stems were rubbed off by means of a piece of hessian cloth.

The rates of application were rather high in the earlier experiment at Tarajulie but these were subsequently reduced.

The efficacy of the treatments was assessed from the number of earth-runs found on the main stem, and these runs were rubbed off immediately after each observation.

Tarajulie experiment, 1953

In this experiment, the dosage rate of Aldrin and Dieldrin was high, being 8 lb. active material per acre. As BHC was recommended previously for control of this termite, it also included as a treatment, the rate being 190 lb. of 5 per cent dust, giving about 1·2 lb. isomer per acre.

In the year of treatments both Aldrin and Dieldrin proved to be significantly superior to other treatments in reducing the incidence of the termite on tea bushes, there being no significant difference in the efficacy of these two insecticides, whereas BHC was moderately effective, its performance being inferior to Aldrin and Dieldrin (Table I).

Table I

Effect of soil treatments on termite incidence

Treatments	Average number of earth-runs per bush		
	Mean of 4 observations during 1953	Mean of 6 observations during 1954	Mean of 6 observations during 1955
Aldrin W.P. at 8 lb. active material/acre	0·24	0·45	0·50
Dieldrin W.P. at 8 lb. active material/acre	0·10	0·23	0·19
BHC 5 per cent dust 190 lb./acre	0·74	0.97	1·32
Check	1·13	1·18	1·30
Significant difference at 5 per cent level	0·31	0·28	0·52

The significant reduction in the incidence obtained with Aldrin and Dieldrin in the year of treatment was maintained in the following two years. Whether this reduction in the second and third year after treatment was due to the destruction of the termite population by the action of the insecticides or due to their persistent action in the top soil preventing the termite from ascending the bushes, could not be ascertained. BHC, however, lost its efficacy from the second year after treatment.

Naharani experiment, 1954

In this experiment the dosage rates of Aldrin and Dieldrin were reduced, each being applied at 2 lb. and 4 lb. active material per acre as a spray with forking. Both Aldrin and Dieldrin significantly reduced the termite incidence in the year of treatment, there being no significant difference in efficacy between these two treatments and between the dosage rates of 2 lb. and 4 lb. per acre. This reduction was maintained in the second year after treatments (Table II).

TABLE II

Effect of soil treatments on the termite incidence

Treatments	Average number of earth-runs per bush	
	1954	1955
Aldrin W. P. at 2 lb. active material/acre	0·11	0·08
Aldrin W. P. at 4 lb. active material/acre	0·03	0·05
Dieldrin W. P. at 2 lb. active material/acre	0·02	0·06
Dieldrin W. P. at 4 lb. active material /acre	0·01	0·04
Check	0·25	0·29
Significant difference at 5 per cent level	0·13	0·09

Tarajulie experiment, 1955

Aldrin as an emulsifiable concentrate was applied at 2 lb. active matrial per acre, the other treatments being oilcake and sulphate of ammonia which were supposed to have some influence in reducing the termite incidence. It is evident from Table III that Aldrin produced a significant reduction in the termite incidence in the year of treatment, whereas the treatments of oilcake and sulphate of ammonia failed to show any significant reduction.

TABLE III

Effect of soil treatments on the termite incidence (1955)

Treatments	Average number of earth-runs per bush
Aldrin E. C. at 2 lb. active material/acre	0·14
Oilcake at 80 lb. N/acre	1·26
Sulphate of ammonia at 80 lb. N/acre	1·31
Check (untreated)	1·51
Significant difference at 5 per cent level	0·34

Silcoorie experiment, 1955

Tea being a perennial crop, planted usually two to five feet apart, in hedges, squares or triangles, presents considerable difficulties in the application of soil insecticides, particularly in forking after application. If the insecticides applied at double the normal rate together with the fertilizers and give effective control without forking, this would be a more desirable method of application. An experiment was, therefore, carried out in young tea with both Aldrin and Dieldrin applied at 2 lb. active material per acre as a spray with forking, and a 4 lb. per acre applied broadcast mixed with fertilizers without forking.

The treatments were applied immediately after the first shower (in the later part of March), so that the insecticide applied broadcast could be absorbed and properly distributed in the soil.

TABLE IV

Effect of soil treatments on termite incidence

Treatments	Number of earth-runs per bush (average of 5 replicates)	
	1955	1956
Aldrin W. P. at 2 lb. active material/acre, as a spray	0·00	0·01
Aldrin E. C. at 2 lb. active material/acre, as a spray	0·00	0·04
Dieldrin W. P. at 2 lb. active material/acre, as a spray	0·00	0·02
Dieldrin E. C. at 2 lb. active material/acre, as a spray	0·00	0·00
Aldrin dust at 4 lb. active material/acre applied broadcast mixed with S. O. A.	0·00	0·00
Aldrin dust at 4 lb. active material/acre applied broadcast mixed with oilcake	0·00	0·00
Dieldrin dust at 4 lb. active material/acre applied broadcast mixed with S. O. A.	0·00	0·00
Dieldrin dust at 4 lb. active material/acre applied broadcast mixed with oilcake	0·00	0·00
Check (untreated)	0·53	0·22

It is evident from Table IV that all the treatments of Aldrin and Dieldrin applied either alone at 2 lb. active material per acre as a spray or mixed with fertilizers at 4 lb. active material per acre effectively checked the termite incidence in the year of treatment. There was no difference between the treatments of Aldrin and Dieldrin, and between the dosage rates of 2 lb. active material per acre applied as a spray with forking, and 4 lb. applied broadcast mixed with fertilizers without forking.

The results were the same even in the second year after application and this reduction was maintained at the same level in all the treatments of Aldrin and Dieldrin.

Borokai experiment, 1955

Both Aldrin and Dieldrin at 2 lb. active material applied as a spray and at 4 lb. mixed with fertilizers and applied broadcast, failed to give any significant reduction in the incidence of the termite in this experiment. The variation in these results from those of other experiments could not be accounted for.

Dieldrin treatment and flush-worm incidence

A few estates which received Dieldrin treatment of the soil against termites, had a more or less severe attack of flush-worm, *Cydia* (*Enarmonia*) *leucostoma* Meyr. in the year of treatment and/or in the following year, and this increase is said to have resulted from Dieldrin application. It has been found that application of persistent insecticides on tea often leads to a increase of certain insect pests by destroying more of their natural enemies than of the pests themselves [Das, 1957]. It was also observed by Baptist [1956] that the use of insecticides with high residual properties for the control of shot-hole borer of flushing tea increased the tea tortrix (*Homona coffearia* Nietner). But it can hardly be explained how Dieldrin applied to soil during the cold weather could increase the flush-worm on tea bushes.

It may be mentioned that a number of estates which have never used Dieldrin on tea or on soil have also been similarly affected by flush-worm ; it appears that the increase of flush-worm is due to changes in climatic conditions or due to the use of persistent insecticides on flushing tea.

Summary and Conclusion

The termites which cause damage to tea bushes can be grouped into two classes : (1) scavenging termites and (2) live-wood eating termites.

Dead and dying tissues resulting from insect damage, fungal attack, pruning cuts, etc. are the main attraction for scavenging termites, and in their absence the bush will hardly suffer from termite attack. The live-wood eating termite will, however, take advantage of such dead and dying tissues to get a foothold on tea bushes, but it may also directly attack healthy wood to gain entrance into the heart-wood even when dead tissues are available. While the scavenging termites usually confine their attack to dead and dying tissues, the live-wood eating termite, *Microcerotermes*, causes damage to the tea bush by attacking living tissues.

Experiments for control of the live-wood eating termites were, therefore, carried out in properly replicated and randomised plots at different tea estates, mostly with Aldrin and Dieldrin at various dosage, applied as a spray and forked into the soil, and applied broadcast mixed with fertilizers without forking. In the earlier trial, Aldrin and Dieldrin at the dosage rate of 8 lb. active material per acre gave highly

significant reduction in the incidence of the termite on tea bushes in the year of treatment and this reduction was maintained at the same efficient level in the following two years, whereas BHC was only moderately effective and its efficacy was lost in the second year.

In the subsequent experiments, the dosage rates of Aldrin and Dieldrin were considerably reduced. Both Aldrin and Dieldrin at 2 lb. and 4 lb. active material per acre applied as a spray gave significant reduction in the incidence of the termite, even in the second year after application, there being no difference between the dosage rates. The rate of 2 lb. applied as a spray was, however, as effective as double the rate (4 lb.) applied broadcast mixed with fertilizers without forking when the application was made after a shower and the soil was wet. Whether Aldrin and Dieldrin at 2 lb. applied broadcast with fertilizers under any weather conditions, would prove as effective as a spray, and how long their persistent action will remain in the soil can only be ascertained by further trials.

Acknowledgement

The author is grateful to the management of Tarajulie, Naharani, Silcoorie, and Borakai Tea Estates for their whole-hearted co-operation in carrying out the experiments on their estates ; Messrs. Julius Hyman and Co., U. S. A., and Burmah Shell and Co., Calcutta, for free samples of the insecticides required in these experiments ; Director, Commonwealth Institute of Entomology, London, for determining the identity of the termites, and the Director, Tocklai Experimental Station, for permitting him to publish the paper.

REFERENCES

Andrews, E. A. (1916). Termites in the Luskerpore Valley. *Quart. J. Indian Tea Assoc.*, **(2)**, 54-72

—— (1923). Termites, *Quart. J. Indian Tea Assoc.* **(4)** ; 118-125

Baptist, B. A. (1956). The tea-leaf eating tortrix caterpillar (*Homona coffearia* Nietn.) as a limiting factor in insecticidal application on tea. *Tea Quart.*, 27 ; 28-35

Das, G. M. (1957). Preliminary observations on the leaf-rollers and leaf-tiers of tea, with special reference to the flush-worm, *Cydia* (*Enarmonia*) *leucostoma* Meyr. in North-East India, *Proc. Zool. Soc.*, Calcutta (in press)

Hutson, J. C. (1923). Notes on termites attacking tea in Ceylon. *Ceylon Dept. Agric. Leaflet* No. 24

Jepson, F. P. (1926). Tea termites in Ceylon. *Quart. J. Indian Tea Assoc.* **(3)** ; 134-142. (reprinted from the *Times of Ceylon*, 9th July, 1926)

Tunstall, A. C. and Sarmah, K. C. (1947). Notes on stem Diseases of tea. *Indian Tea Assoc. Mem.* No. 16 ; 51.

GLYPHODES BIVITRALIS GUEN., AS A NEW PEST OF JAK

By K. R. Nagaraja Rao and T. R. Subramaniam, Agricultural Research Institute, Coimbatore

[Received for publication on September 7, 1957
Accepted for publication on September 9, 1957]

In South India, about eight species have been recorded under the genus *Glyphodes* (family *Pyralidae*). Amongst these, *Glyphodes indica*, Saund., and *Glyphodes caesalis* Wlk. are given the status of crop pests since they cause appreciable damage to cucurbitaceous plants and Jak (*Artocarpus integrifolia*) respectively. The latter is a leaf folder and more often bores into the terminal shoots as well.

During February, 1957, an instance of a pyralid caterpillar causing considerable injury to the foliage of jak trees was noticed at the Fruit Research Station, Kallar (Madras State). The general appearance and habits of this pest differed considerably from those of *Glyphodes caesalis* Wlk. A large number of the caterpillars was, therefore, collected and kept under rearing. The adults that emerged have been determined as *Glyphodes bivitralis* Guen. A brief account of the information gathered on this pest, is furnished in this article.

Moore [1884] and Hampson [1896] have recorded *Glyphodes bivitralis* Guen. on *Ficus oppositifolia*. Fletcher [1919] has been able to rear the caterpillars on pods of *Cajanus indicus* at Pusa. Senior White [1919] makes mention of this pyralid as a pest of *Ficus religiosa* and *Ficus glomerata* at Ceylon. The recent occurrence of this species on jak, therefore, appears to be a new record for India.

Symptoms of damage : An affected tree can easily be spotted out by the presence of a large number of webbed leaves, bound together by means of silken strands secreted by the larvae. The caterpillars are gregarious and remain inside such folds scraping and feeding on the leaf tissues. The foliage gradually loses the green colour and is rendered parchment like, the yield being affected ultimately.

Adult : The adult is a medium sized moth with a wing expanse of 32-34 mm. The head, the thorax and the abdomen are chestnut brown in colour above and white beneath. The forewing is also of the same colour, having markings in the form of two semihyaline whitish spots and a small black spot in between the two. The hindwing is hyaline white with a broad chestnut marginal band, having a black line at its inner edge. The male has a black anal tuft.

Caterpillar : The caterpillar is elongated and olive brown in colour, measuring about 30 mm. in length when full grown. There are a number of dorsal, subdorsal and lateral series of white dots on the body ; a few black ones are also found on thoracic and abdominal segments. The head is reddish with a black lateral streak. The caterpillars attain full growth in 14 to 16 days, undergoing generally five moults.

Pupa : Pupation takes place within leaf folds and inside a thin white silken cocoon. The pupa is pale red with a long antennal sheath, a sharp anal point and measures on an average about 22 mm. in length. The adult emerges in 8 to 10 days.

Control : BHC spray at 0·1 per cent strength (one pound of 50 per cent wettable powder in $6\frac{1}{2}$ gallons of water) applied in such a way as to get an entry into the webbed leaves, causes a cent per cent mortality of the caterpillars.

ACKNOWLEDGMENT

The financial assistance rendered by the Indian Council of Agricultural Research in respect of a scheme under the auspices of which the observations were made is acknowledged with thanks. The authors are thankful to the Government Entomologist, Coimbatore and the Assistant Fruit Specialist, Coonoor for giving the necessary facilities to pursue the work.

REFERENCES

Fletcher, T. B. (1919). Annotated list of Indian Crop pests *Proc. IIIrd Entl. Meet. Pusa ; 131*

Hampson, G. F. (1896). *Fauna. Brit. India. Moths* **4** : 355

Moore, F .(1884). *Lepidoptera of Ceylon* **3** : 322

Senior White, S. (1919). A list of Lepidoptera noted to attack cultivated plants in Ceylon. *Proc. IIIrd Entl. Meet. Pusa ;* 336.

EFFECT OF TOMATO VIRUS ON INFECTION OF BEAN PLANTS BY TOBACCO MOSAIC VIRUS

By B. B. Nagaich[1], Department of Plant Pathology, University of Illinois, Urbana

[Received for publication on August 8, 1957
Accepted for publication on September 3, 1957]

IT was reported by Beale [1947] that the Ribgrass strain of tobacco mosaic virus though non-infectious to Early Golden cluster bean interfered with the infection of bean plants by the common strain of tobacco mosaic virus (referred to hereafter as TMV). Miller [1953] isolated a tobacco mosaic type virus (designated as V-52-1) which did not produce necrotic local lesions on bean varieties susceptible to TMV. Later this negative reaction of TMV susceptible varieties to the tomato virus was confirmed by Nagaich [1957]. It, therefore, appeared worthwhile to know whether this tomato virus would or would not interfere with the infection of bean plants by TMV.

Materials and Methods

Viruses used in these studies were *Marmor tabaci* Holmes, Johnson's strain No. 1 and V-52-1 of Miller (1953). Both of these viruses were increased in Turkish tobacco (*Nicotiana tabacum* L.) plants.

Crude inocula were obtained by grinding diseased tobacco leaves in a household food grinder and then separating the juice from the pulp by straining through two layers of cheesecloth.

Purified viruses were the preparations obtained by two differential sedimentations in an ultracentrifuge (Spinco model L.). The centrifugations for clarifications were at 5,000 G for 15 minutes. The first centrifugation for sedimentation was at 40,000 G for 3 hours and the second at 80,000 G for 2 hours. The resulting pellets from the viral sedimentations were suspended in 0.1 molar sodium phosphate buffer at *p*H 7·0 (1/10th of the corresponding supernatant volume). Protein content of the final preparations of the two viruses was computed from nitrogen analyses by the microkjeldahl method. Desired concentration of viral protein was obtained by diluting the final samples in the required volume of buffer.

The assay plant employed in these studies was Pinto bean (*Phaseolus vulgaris* L.). After 14 days from the time of sowing, when the primary leaves attained the proper size for inoculation, the growing tips of the plants were pinched off and the inoculum was applied to the surface of the leaves as stated below. Since the susceptibility of bean varieties varies from plant to plant, the opposite leaf method of assay was used in these studies.

[1]These studies were conducted while the author was on a graduate college fellowship of the University of Illinois, Urbana. His present address is, Plant Pathological Substation, Flowerdale, Simla.

Inoculation consisted in the stroking of upper surface of the leaves of test plants with uniform cheesecloth pads dipped in the inoculum. Just prior to inoculation approximately 7 per cent of abrasive (by weight), aluminum oxide powder, was added to the virus suspensions. Care was taken to inoculate the entire surface of the leaves uniformly and to avoid duplicate stroking of any area. After inoculations leaves were washed in running tap water to remove substances that might injure the leaves.

Infectivity of the various samples assayed was estimated from the number of necrotic local lesions counted 4-6 days after the inoculation.

Experiments and Results

Effect of proportion of tomato-virus crude extract on infection of bean plants by TMV.

Crude inoculum of TMV was diluted in various amounts of the crude juice from tomato-virus-infected tobacco plants as designated in Table I. For control, TMV was similarly diluted in different amounts of distilled water. After thorough mixing each of the preparations was further diluted 1 : 500 in 0·1 molar sodium phosphate buffer at *p*H 7·0 for the estimation of infectivity.

The results in Table I show that tomato-virus crude extract partially inhibits infection of bean plants by TMV in the crude inoculum, and that the amount of inhibition is related to the proportion of tomato-virus crude extract in the inoculum.

Table I

Effect of varying amounts of the tomato-virus crude extract on the infection of bean plants by TMV in the crude inoculum

Inoculum		Average No. of lesions per leaf*	Lesions as per cent of control on the opposite leaf
TMV	Diluent		
1 part	9 parts tomato virus extract	77±27	69
1 part	9 parts distilled water	113±18	100
1 part	99 parts tomato virus extract	39±23	58
1 part	99 parts distilled water	67±16	100
1 part	999 parts tomato virus extract	14± 7	48
1 part	999 parts distilled water	29±15	100

* =Average of lesions on 16 leaves in two experiments.
±=Standard error.

Effect of concentration of tomato virus protein on the infection of bean plants by TMV.

Partially purified TMV (2·5 mg. protein per ml.) was diluted 1 : 10 in purified tomato-virus preparations of different protein concentrations. These preparations were then inoculated to one leaf of each test plant. The opposite leaves were inoculated with TMV diluted 1 : 10 in 0·1 molar, *p*H 7·0 sodium phosphate buffer, to serve as control.

The results in Table II show that purified tomato, virus partially inhibits the infection of bean plants by purified TMV and that the amount of inhibition is relative to the concentration of purified tomato, virus protein present in the inoculum.

TABLE II

Effect of various concentrations of purified tomato virus on the infection of bean plants by TMV in purified preparations

Inoculum		Average No. of lesions per leaf*	Lesions as per cent of lesions on the opposite leaf
Concentration of TMV protein	Diluent		
0·25 mg./ml.	Tomato virus (12·5 mg. protein/ml.)	394±64	79
0·25 mg./ml.	Buffer	495±88	100
0·25 mg./ml.	Tomato virus (5 mg. protein/ml.)	432±90	90
0·25 mg./ml.	Buffer	477±101	100
0·25 mg./ml.	Tomato virus (2·5 mg. protein/ml.)	460±83	93
0·25 mg./ml.	Buffer	491±92	100

*=Average of lesions on 16 leaves in two experiments.
±=Standard error.

DISCUSSION AND CONCLUSION

It is evident from the results that crude juice or purified tomato-virus, whenever mixed with TMV, partially inhibits the infection of bean plants by TMV. These results are in agreement with those of Beale [1947] on the inhibition of viral infections, and those of Yarwood [1957] on the inhibition of fungal infections, i.e. uredospores of *Uromyces phaseoli* (Pers.) Wint. although non-infectious to sunflower, protected sunflower leaves from infection by *Puccinia helianthi* Schw., and also uredospores of *P. helianthi* Schw. although non-infectious to beans, immunized bean leaves against *U. phaseoli* (Pers.) Wint. Both of these workers found that this interference phenomenon was more pronounced if high concentrations of the inhibiting virus or interfering organisms were present. The results of the present studies also show that, the concentration of the inhibiting substance(s) influence(s)the inhibition of infection ;

higher the concentration of purified tomato-virus or the proportion of tomato-virus extract the greater the inhibition of infection of bean leaves by TMV. It is apparent that the crude tomato-virus extract inhibits infection more strongly than does the purified preparation of tomato-virus. This is apparently due to the presence of some substance or substances in the crude tomato-virus extract which were removed during purification. These inhibiting substances of the crude tomato virus extract may be proteins of enzymatic activity since several enzymatic proteins are strong inhibitors of infection of beans by TMV [Dale and Thornberry, 1955], and since enzymatic proteins are commonly present in plant extracts.

The actual mechanism of the inhibition of infection by purified tomato-virus or other substances present in the crude juice is not clear from the above studies, but it is theorized that the infection may have been inhibited in one or more of the following ways : (1) by combination of these substances with TMV to form a non-infectious complex, (2) by formation of a protective covering over the injured cells so as to prevent entry of TMV into the cells, or (3) by an unfavourable action of these substances on the increase of TMV after its entry in the host cells.

Summary

The tomato-virus, in spite of its non-infectiousness to Pinto beans, reduces the number of local lesions on Pinto bean leaves capable of resulting from the inoculation with TMV.

The reduction of the number of local lesions resulting from inoculation with TMV is related to the proportion of tomato-virus extract in the inoculum.

The reduction of local lesions developing on inoculation with TMV also depends on the concentration of the tomato-virus protein in the mixture.

The inhibition of infection brought about by the purified virus is less than the inhibition brought about by the crude juice from diseased plants.

Some possible ways of inhibition of infection are suggested.

Acknowledgement

The author thanks Dr. H. H. Thornberry for suggestions in the preparation of the manuscript and the Department of Plant Pathology for providing the facilities for the work.

REFERENCES

Beale, H. P. (1947). The interference phenomena between Ribgrass and tobacco mosaic viruses in bean. *Phytopathology* (abstracts) **37** : 847

Dale, J. L. and Thornberry, H. H. (1955). Effect of some compounds and biological products upon infection by tobacco mosaic virus. Ill. *Acad. Sci., Trans.* **47** : 65-71

Miller, P. M. (1953). An apparently new virus disease of tomatoes in Illinois. *Phytopathology* (abstracts) **43** : 480

Nagaich, B. B. (1957). Characterization of a " tobacco-mosaic type " virus obtained from tomato. Ph. D. Thesis, Univ. of Ill. Library, Urbana.

Yarwood, C. E. (1956). Cross protection with two rust fungi. *Phytopathology* **46** : 540-544.

A NOTE ON THE OCCURRENCE OF LITTLE LEAF IN CLOVE

By M. A. Balasubramaniam

[Received for publication on July 31, 1957
Accepted for publication on September 19, 1957]

(With 1 Text-Figure)

THE clove, *Syzigium aromaticum* (Syn. *Eugenia caryophyllata*) is largely cultivated in many parts of the tropics and the sub-tropics. The tree is very hardy, long lived and reported to be largely free from pests.

A survey of the clove growing tracts of the Indian Union was conducted during 1955-56 under a scheme sponsored by the Indian Council of Agricultural Research for the improvement of clove, nutmeg and cacao. The bulk of the clove trees at the Black Rock Estate in the Kanyakumari district of Madras were normal. However, one tree of 25 years age exhibited complete repression of all tree and vegetative characters. The tree was 10 feet 6 inches in height and of 5 inches in trunk girth with an all round spread of 2 feet 6 inches. The trunk was observed to be showing numerous protuberances. The branches were arising at four feet from the ground level, being held at an acute angle with the trunk giving a cone shaped appearance to the whole tree. They were slender and curved at the middle away from the trunk with the leaves arranged at very close internodes giving the shoot the appearance of a bottle-brush. The primary and secondary branches were seen arising closer and becoming shorter towards the periphery of the tree. The leaves were seen arising at closer internodes and to be getting reduced in size and shape from the base to the apex of the shoot. The length of the leaf including the petiole ranged from 1·0 to 6·0 cm., the breadth from 0·15 to 1·3 cm. while the length of the petiole ranged from 0·1 to 1·1 cm. while in a normal tree the length of the leaf including the petiole, ranged from 10·10 to 14·00 cm., and the breadth from 4·00 to 5·50 cm. and the petiole from 1·30 to 2·90 cm. in length (Fig. 1).

The tree did not show any other symptoms of disease such as leaf spots, etc. The tree is reported not to have come to flowering at all so far. Mr. C. H. Simpson, the owner of the estate had observed three similar types in his old plantings which he found to be loop rooted with characteristic goose-neck formation.

Tidbury [1949] does not mention any similar disease of clove but suggests that the " sudden-death " disease might be of viral origin, of which Nutman [1950] has [Nutman, Sheffield 1950] since confirmed the fungal origin, and of which the symptoms are totally different from the ones described here. The characteristic subnormal reduction of all tree and vegetative characters and the complete suppression of flowering suggests that this abnormality may probably be of viral origin as in the well known " spike " disease of the sandal tree. This is the first time that such symptoms have been noticed in clove. A detailed pathological examination of this tree may be worthwhile.

FIG. 1. (A) normal shoots of clove ; (*a*) subnormal shoots.

ACKNOWLEDGMENT

The author is grateful to Dr. K. Ramakrishnan, Government Mycologist, Coimbatore, for guidance in the preparation of this note.

REFERENCES

Nutman, F. J. (1950). Hort. Abstr. V. **23**, No. 4 (4590)

Nutman, F. J. and F. M. L. Sheffield. 1950. " Sudden death disease and its epidemiology " *Hort. Abstr.* V., 10 No. 3 (2,000)

Ridley, H. N., (1912) " *Spices* ", Macmillan and Coy., New York

Tidbury, G. E., (1949). " *The clove tree* " Crossby Lockwood and Sons Ltd., London

Yegna Narayan Aiyer (1938). "Report on an enquiry into the cultivation of cloves in India ". *I.C.A.R. Bull.* No. 20.

TERPENYL ANALOGUES OF PARATHION (AS INSECTICIDES)

TERPENE SERIES (III)

By V. V. Bhatia, R. S. Dewan, A. R. S. Kartha and K. C. Gulati, Indian Agricultural Research Institute, New Delhi

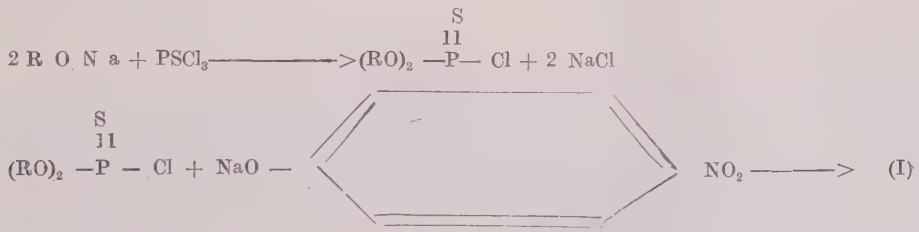
[Received for publication on March, 23, 1957
Accepted for publication on August, 17, 1957]

THE organic phosphorus compounds are being used as contact and stomach poisons, as fumigants, as well as systemic insecticides. O, O'-diethyl, O-p-nitrophenyl thionophosphate (I), being one of the outstanding compounds.

Where R = $-C_2H_5$; $-C_{15}H_{25}$; $C_{11}H_{17}$,

(I) $-C_{10}H_{17}$

In connection with relation of chemical constitution of parathion derivatives to their toxicity, it has been found that methyl and ethylesters are more effective as insecticides than higher homologues. A number of highly effective chloro and thiocyano-insecticides, built upon cyclic terpene nuclei are known. In this investigation attempt has been made to prepare the terpenyl analogues of parathion according to the procedure of Fletcher and Hamilton, [1950] using longifolyl, nopyl and bornyl alcohols without affecting any alteration in the nitro phenyl residue of the molecule.



R = $C_{15}H_{25}$ — Or $C_{11}H_{17}$ — Or $C_{10}H_{17}$

Screening tests indicate that the compounds have appreciable toxicity to insects. Insects used being *Euproctis lunata*, *Corcyra cephalonica* and *Tribolum castaneum*. However, the toxicity was less than parathion (I) to all the three insect species.

At 1·4 per cent concentration in the form of emulsion against *E. lunata* and *C. cephalonica*, the order of toxicity was longifolyl analogue (II)>nopyl analogue (III)> bornyl analogue (IV). Further comparison of toxicity of these samples at 0·036 per cent and 0·013 per cent against *T. castaneum* beetles, the longifolyl analogue gave cent per cent mortality at both the concentrations in 24 hours, while in case of nopyl and bornyl analogues the mortality was 50 per cent and 60 per cent, respectively at higher concentrations and 20 per cent and 35 per cent respectively at lower concentrations.

The compounds as studied are fairly efficacious though less toxic than parathion to the insects. It may be of interest to study further the toxicities of the compounds of this series against vertebrates *vis-a-vis* the parathion.

Experimental

Longifolyl alcohol

Longifolyl alcohol [Sat bir 1950 ; Chattarji and Gulati, 1952] used in the investigation was prepared from sesquiterpene longifolene by first converting it into longifolyl-acetate, the hydrolysis of the acetate with alcoholic caustic potash, removal of ethyl alcohol by distillation, and removal of unreacted terpene by steam distillation and subsequent vaccum distillation of the product.

Nopol

A sample of the alcohol [Bains 1946] for investigation was obtained from Dr. J. P. Bains of Glidden and Co. Jacksonville, Fla., (U.S.A.). Nopol was also obtained in poor yields by the condensation of β-pinene with paraformaldehyde in presence of zinc chloride as catalyst, at ordinary pressure. Borneol used was a B.D.H. product.

O·O diterpenyl chloro-thiophosphate

Granular sodium prepared in the convertional way was taken in an one litre three-necked flask and covered with 200 ml. of anhydrous ether. The flask was fitted with a dropping funnel, a stirrer and reflux condenser and protected with adequate guard tubes. The whole outfit was placed on water bath, the terpenic alcohol (a little less than 0·5 mole) was added in course of two hours from the dropping funnel under stirring. Stirring and refluxing was continued for further six to eight hours, till almost no further sodium reacted. The sodium terpenyl alcoholate (in suspension) was transferred to another three-necked flask fitted with dropping funnel ; stirrer and thermometer, with a view to get rid of unreacted sodium. It was cooled in ice bath and phosphorus thiochloride (0·25 mole), dissolved in 80 ml. of benzene, was added dropwise in course of three hours to the stirred mixture, care being taken that the temperature did not rise above 10°C. The stirring was further continued for three hours and the reaction mixture was allowed to stand overnight under anhydrous conditions.

The reaction product had an appearance of white emulsion. It was concentrated to thick slurry under vacuum (at a pressure of 80 mm.) on water bath heated to 60°C. The thick slurry was transferred to a separating funnel and 70 ml. of benzene and 150 ml. of water were added to it. The mixture was well shaken, and the upper reddish brown layer of benzene extract separated. The colourless aqueous layer was extracted with two 15 ml. portions of benzene. The combined benzene extract was washed with water and dried over anhydrous sodium sulphate, prior to attempting fractional distillation under vacuum. At 18-20 mm., the vacuum obtainable with the available facilities, the products showed a tendency to decompose.

O'O'-dilongifolyl chlorothiophosphate

Longifolyl alcohol (purity, 80 per cent, 120 g., sodium 11·5 g. (out of which only about 7·5 g. reacted), and phosphorus thiochloride, 42 g. were reacted together. Most of the product distilled over at 145-50°C had a purity of 68·7 per cent, yield 33 g. This is likely to contain some unreacted alcohol and appears to be less heat susceptible than the corresponding products from nopol and borneol.

O'O'-dinopyl chlorothiophosphate

Nopol (92 g.), sodium (11·5 g.) and phosphorus thiochloride (42 g.) were reacted together. After the removal of benzene, etc., when attempt was made to fractionally distill the product, it was found to be highly heat susceptible and underwent spontaneous decomposition at 115°/18 mm. No further attempt was made to purify it and it was used as such in subsequent reactions. The product had a purity of 52·5 per cent.

O'O'-dibornyl chlorothiophosphate

Borneol (60 g.), sodium (10 g.) and phosphorus thiochloride (38 g.) were reacted together, the crude product after removal of benzene, etc., weighed 72 g. (purity 43 per cent). The product had a reddish brown colour, and it underwent decomposition when attempt was made to distill it at 18 mm. pressure.

In view of the fact that products obtained were impure and were susceptible to decomposition and also the fact that parathion and related compounds are sensitive to isomerization, when heated, [Metcalf and March, 1953] no attempt was made to purify the product and the intermediates further and their percentage purities were assessed on the basis of chlorine content by Stepnov's method, sulphur with bomb calorimeter and phosphorus by oxidation with hydrogen peroxide [Scot and Furman 1939]. The results obtained are given in Table I and II.

Percentage purities as found on the basis of chlorine, phosphorus and sulphur content are somewhat varying due to the products being impure. However, for the purpose of further reaction of the diterpenyl chlorothiophosphates with p-nitrophenol, chlorine content was taken as the index of purity.

TABLE I

Percentage purities of Terpenyl chlorothiophosphates

Terpenyl Chlorothiophosphate	Chlorine			Phosphorus			Sulphur		
	Found (per cent)	Calculated (per cent)	Percentage purity	Found (per cent)	Calculated (per cent)	Percentage purity	Found (per cent)	Calculated (per cent)	Percentage purity
O·O′-dilongifolyl chlorothiophosphate ($C_{30}H_{50}O_2ClPS$)	4·41	6·57	67·11	3·72	5·74	64·8	3·42	5·92	57·77
O,O′-dinopyl chloro-thiophosphate ($C_{22}H_{34}O_2ClPS$).	4·32	8·28	52·18	3·63	7·24	50·14	3·75	7·46	50·26
O.O′-dibornyl chloro-thiophosphate ($C_{20}H_{34}O_2ClPS$).	3·74	8·78	42·60	3·23	7·66	42·17	..	..	..

TABLE II

Percentage purities of Terpenyl analogues of Parathion

O, O′-diterpenyl-O-p nitrophenyl thionophosphate	Phosphorus			Sulphur		
	Found (per cent)	Calculated (per cent)	Percentage purity	Found (per cent)	Calculated (per cent)	Percentage purity
O.O′-dilongifolyl-O-p nitrophenyl thionophosphate ($C_{36}H_{54}O_5NPS$).	3·15	4·82	65·36	3·26	4·98	65·48
O.O′-dinopyl-O-p nitrophenyl thionophosphate ($C_{28}H_{38}O_5NPB$).	2·82	5·84	48·28	3·00	6·03	49·75
O.O′-dibornyl-O-p nitrophenyl thionophosphate ($C_{26}H_{38}O_5NPS$).	2·46	6·12	40·19	2·58	6·31	40·89

O·O′-diterpenyl-O-p-nitrophenyl thiono-phosphate

Equimolar quantities (0·02 mole), O, O′-diterpenyl chlorothio-phosphate (after taking into account the presence of impurities), p-nitrophenol (recrystallized from benzene) and finely ground anhydrous potassium carbonate, along with 200 ml. of dry acetone, were mixed in a three-necked flask, fitted with a reflux condenser and a stirrer. The whole mixture was stirred and refluxed (50-64°C) on a water bath for five hours. After cooling to room temperature, the reaction mixture was filtered and the residue washed with small quantity of acetone. The filtered solution was deep yellow in colour. Most of the acetone was removed by distillation on water bath the last traces of the solvent being removed under vacuum. There was a separation of small quantity of yellow crystals (identified as sodium salt of p-nitrophenol).

The residual oil (10 g.) was dissolved in 200 ml. of ether and the solution was washed repeatedly with 10 per cent sodium carbonate solution, till the washings were colourless. The ethereal layer was then dried over anhydrous sodium sulphate, ether distilled off, last traces of ether were removed under vacuum and heating on water bath. The residual oil was taken as the terpenyl analogue of parathion and was tested for insecticidal activity. All the thionophosphates had faint pleasant odour unlike parathion which has garlicky odour. The pleasant odour of the analogues may be due to the presence of unreacted terpene alcohols as an impurity.

O·O′-dilongifolyl-O-p-nitrophenyl thiono-phosphate

O. O′-dilongifolyl chlorothio-phosphate, 16 g. (purity 68 per cent) on reacting with p-nitrophenol, gave 14·5 g. of the product, yellow in colour.

O·O′-dinopyl-o-p-nitrophenyl thiono-phosphate

O, O′-dinopyl chlorothio-phosphate, 54 g. (purity 52 per cent) on reacting with nitrophenol, gave 52 g. of the thick dark brown material.

O·O′-dibornyl-O-p-nitrophenyl thiono-phosphate

O, O′-dibornyl chlorothio-phosphate, (40 g., purity 42 per cent) and p-nitrophenol gave 28 g. of the brown oil.

The crude O, O′-diterpenyl O-p-nitrophenyl thionophosphates, when assessed for their purities by determination of phosphorus and sulphur separately, gave the results as in Table II.

Summary

Longifolyl, nopyl and bornyl analogues of parathion have been prepared in purity of 65, 49 and 40 per cent respectively. The compounds were tested for insecticidal activity (after taking into account the impurities) against *Eurproctis lunata*, *Corcyra cephalonica* and *Triboleum castaneum* and showed appreciable toxicity. Longifolyl analogue exhibited the highest degree of toxicity, though it was less than that of parathion.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. S. Pradhan, Toxicologist of the Institute for carrying out the bio-assay. They also thank Dr. S. P. Raychaudhuri, Head of the Division of Soil Science and Agricultural Chemistry and Dr. B. P. Pal, Director of the I.A.R.I. for their interest in the work.

REFERENCES

Ripper, W. E., Greenstand, R. M. and Leckerish, L.A. (1949). *J. Econ. Entomol.*, **42**, 721

Fletcher, J. H. and Hamilton, J. C. (1950). *J. Amer. Chem. Soc.*, **72**, 2461

Sat Bir Chatterjee, B. G. and Gulati, K. C. (1950, 1952). M.Sc. thesis, Punjab University. Indian Patent No. 47715- (to Director, I.A.R.I., New Delhi)

Bains, J. P. (1946). *J. Amer. Chem. Soc.*, **'68**, 638

Metcalf, R. and March, R. (1953). *J. Econ. Entomol.*, **'46**, 288

Scot and Furman (1939). *Standard Methods of Chemical Analysis*, 5th Ed , **2**, 2499.

STUDIES ON THE VEGETATIVE PROPAGATION OF CASHEW (*ANACARDIUM OCCIDENTALE* LINN.)

IV—THE NURSE-GRAFTED Y-CUTTING METHOD

V. N. Madhava Rao and I. K. Sambashiva Rao, Central Cashewnut Research Station, Mangalore

[Received for publication on January 7, 1957
Accepted for publication on February 22, 1957]

(With 1 text-figure

IN order to devise a suitable method of vegetative propagation of cashew, trials have been in progress at the Central Cashewnut Research Station, Mangalore since 1953. Among the several methods under trial, air-layering of one-year old and current season's shoots, and inarching (approach grafting) were found feasible[1,3]. Yet another method which has been found successful is the Y-cutting method or the nurse-grafted Y-cutting method. The details of the trial are presented in this paper.

Review of Literature

The Y-cutting method or the nurse-grafted Y-cutting method was devised by Robinson for rooting cuttings of citrus species such as *Balsamocitrus Dawei*, sweet orange and the Wase satsuma of Japan, which had proved very difficult to grow from cuttings or air-layers[5]. It is claimed that this method has never yet failed with any citrus plant. Oliver[4] successfully adopted the method for propagating the mangosteen. The process as devised by Robinson consists essentially in inarching a seedling plant to a Y-shaped leafy branch of the tree it is desired to propagate. The roots of the attached plant which will serve eventually as a root-stock are kept fresh by encasing them in a packet of moist sphagnum moss wrapped in a waxed paper and watered when necessary and tied to the mother plant for security. Recently a marcottage box to hold the roots has been used. In two weeks, the Y-shaped scion and the nurse graft begin to unite. The Y-branch is then completely ringed below the fork of the Y, $\frac{1}{8}$ to $\frac{1}{4}$ inch width of the bark being removed. This causes the accumulation of reserve food material moving down from the leaves, a condition which favours the speedy production of roots when the cutting is eventually planted. In four to eight weeks, when union with the nurse graft is complete, the Y-branch is cut through at the ring. The root of the nurse graft is released from its waxed chamber, and both it and the

forked cutting still attached are placed in a rooting medium in a humid bottom-heated propagating pit. Soon the Y-cutting puts out new roots and the rooted portion of the Y-cutting is separated from the nurse graft. Thus two independent plants are obtained, one upon its own roots and the other on a rootstock.

In the method described above, actual rooting of the ringed shoots commences in the green house where they are buried in beds along with the graft. At the time of separation from the parent tree, therefore, only callussing and possibly the initiation of rooting would be seen at the ringed portion. In cashew, however, the earlier success noticed in air-layering with the use of plastic film wrappers rendered it possible to allow the ringed shoots to root even while on the parent tree.

In the first part of the trials reported in this paper, which are partly based on Robinson's method, cashew seedlings 'potted' in hill grass containers were used for grafting and watered periodically, but in the later trials a further improvement was attempted by introducing Alkathene plastic film wrappers as containers for the rootstock seedling, thereby eliminating the need for frequent watering of the nurse-graft. The use of the plastic film wrappers has, therefore, rendered it possible to introduce vital modifications to Robinson's method substantiating the belief of Swingle *et al.*[5], that the method which has hitherto been employed under green house conditions can be used out of doors if precaution is taken to attach the nurse graft firmly to the tree and to protect its roots from drying, preferably by using a paraffin coated marcottage box, which will insure even moisture conditions without frequent attention to watering. With such a device, he said, the time required for rooting the Y-cutting may be shortened in many cases and rooting made more certain.

A further modification of the above method involving the inarching and air-layering simultaneously instead of a time-lag of four weeks between the operations, was also tried in cashew.

Material and Methods

Trials on the nurse grafted Y-cutting method were initiated in November, 1954 with cashew trees in plantations adjoining the Cashew Research Station, Ullal, Mangalore. The method is described below.

Inarching of one arm of a Y-shaped shoot was done as in Robinson's method but with the rootstock seedling held in hill grass receptacles containing soil and manure mixture. The ringing of the main shoot below the fork of the Y was done four weeks after inarching. While in the Robinson's method, no further treatment was done, in the present trial, moist moss was applied over the ringed portion, and the treated shoot was wrapped with 100-gauge Alkathene plastic film, the ends of which were secured with twine. The nurse-graft was watered whenever necessary while the ringed shoot did not receive any watering. With the signs of rooting as evidenced by the appearance of roots through the transparent film, the Y-cutting was separated from the tree with the grafted arm in tact. The graft and the Y-cutting (layer) were then placed in a rooting medium in the nursery and

separated from each other after the cutting put forth new shoots. Thus a graft and a rooted cutting (air-layer) are obtained from a single Y-shaped shoot. Ten shoots were worked per month from November, 1954 to October, 1955 in monthly batches.

With a view to examining the possibilities of eliminating watering of the nurse-graft while on the tree, the ' grassed ' seedling to serve as rootstock for the nurse-graft was wrapped with 100-gauge Alkathene film and then inarched. No watering was done subsequently. The ringing or air-layering of the main limb, the separation of the graft and the rooted layer were done as before. The modified trial was conducted for six months from August, 1955 to October, 1955 and from March, 1956 to May, 1956, to study in particular, whether the latter batches raised in the summer months, would give rise to grafts and layers, suitable for planting during the monsoon rains between June and August on the west coast of India.

A further modification of the above trial with the seedling rootstocks wrapped in Alkathene film and in which both the air-layering and grafting were done simultaneously instead of allowing an interval of four weeks between the operations was attempted in March, April and May, 1956. A similar batch wherein the air-layering was done a month after grafting served as a ' control '.

Results

A summary of the results, in the original method under which the seedlings intended for inarching were in grass containers and the air-layering was done about a month after inarching is given in Table I.

It may be seen from Table I that—

(i) On an average, six grafts and four layers resulted from 10 Y-shaped shoots.

(ii) The maximum success was obtained with the batch prepared in February, 1956 when 10 grafts and 10 layers (i.e.) 20 clones were successfully separated from 10 shoots operated.

(iii) The season between December-April, which coincides with the period of intense growth activity appeared more congenial from the point of view of both the success and the availability of the plants for planting in the monsoon season in June.

A comparison of the time taken for rooting showed that as against a mean period of 63 days from the date of air-layering in the normal method the air-layers in the Y-cutting method rooted in 51 days. It was also seen that the air-layered shoots in the Y-cutting trial worked in January rooted in the earliest period of 30 days as against the earliest period of 40 days by the conventional method of air-layering. The maximum time taken for rooting was also seen to be less in the Y-cutting method, being 69 days against 90 days by the conventional method. That there is a tendency for earlier rooting in the Y-cutting method is, therefore, indicated.

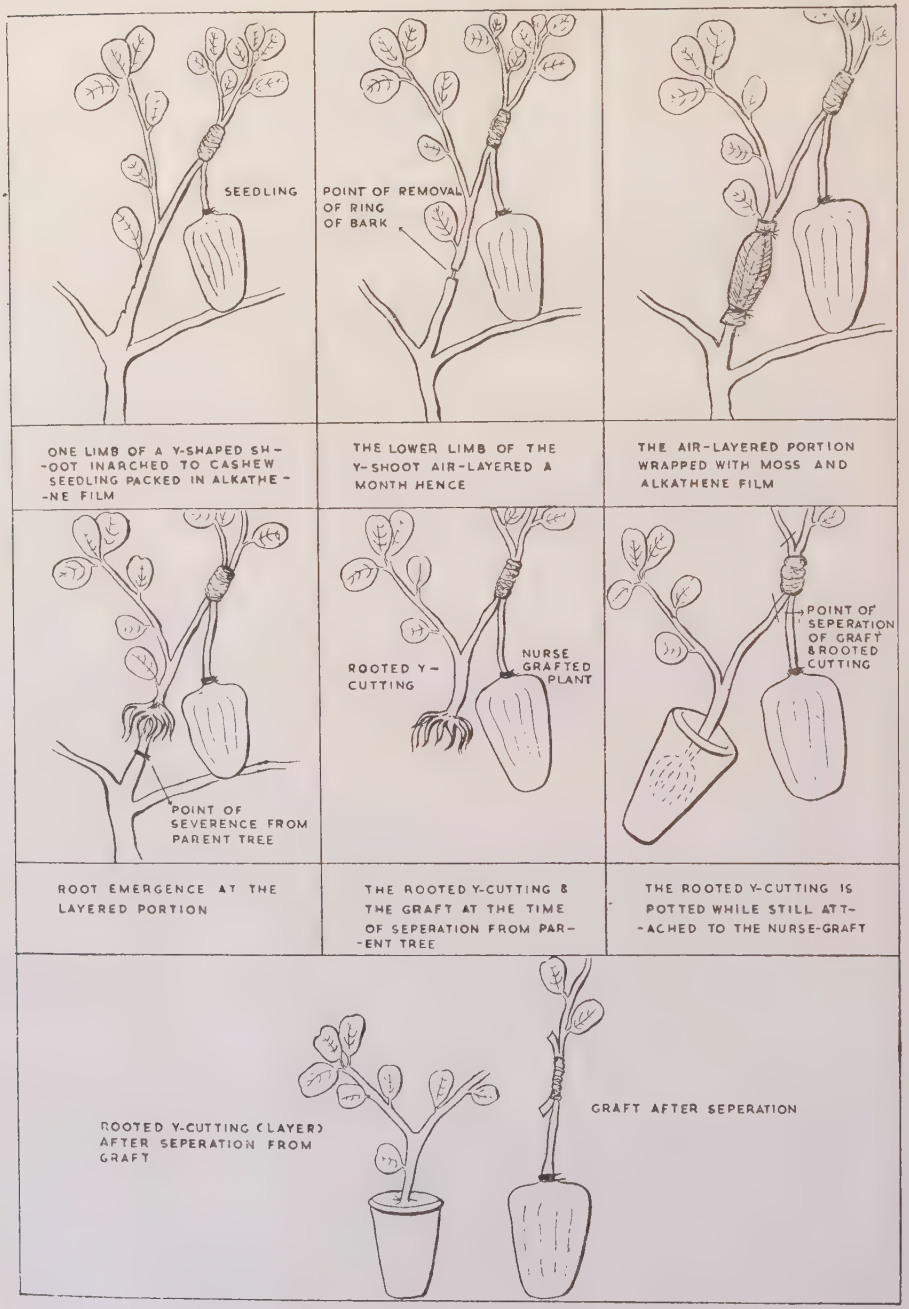

SEEDLING
POINT OF REMOVAL OF RING OF BARK
ONE LIMB OF A Y-SHAPED SH--OOT INARCHED TO CASHEW SEEDLING PACKED IN ALKATHE--NE FILM
THE LOWER LIMB OF THE Y-SHOOT AIR-LAYERED A MONTH HENCE
THE AIR-LAYERED PORTION WRAPPED WITH MOSS AND ALKATHENE FILM
ROOTED Y-CUTTING
NURSE GRAFTED PLANT
POINT OF SEVERENCE FROM PARENT TREE
POINT OF SEPERATION OF GRAFT & ROOTED CUTTING
ROOT EMERGENCE AT THE LAYERED PORTION
THE ROOTED Y-CUTTING & THE GRAFT AT THE TIME OF SEPERATION FROM PAR--ENT TREE
THE ROOTED Y-CUTTING IS POTTED WHILE STILL ATT--ACHED TO THE NURSE-GRAFT
ROOTED Y-CUTTING (LAYER) AFTER SEPERATION FROM GRAFT
GRAFT AFTER SEPERATION

FIG. 1. Y-cutting method of propagation of cashew.

TABLE I

Results of Y-cutting method of grafting

No. done per month : 10

Month of operation	No. of days for layering since date of inarching	Period (days) taken for rooting from the date of layering	No. separated successfully			Total period for separation (days)
			Grafts	Layers	Total No. of clones out of 10 shoots worked	
1954—						
November	54	55	4	3	7	134
December	48	39	9	7	16	125
1955—						
January	33	30	5	5	10	104
February	33	31	10	10	20	100
March	31	37	8	5	13	137
April	30	64	6	3	9	123
May	31	65	5	2	7	138
June	30	59	8	8	16	127
July	31	37	7	2	9	108
August	34	61	1	1	2	143
September	29	69	3	1	4	139
October	35	59	4	2	6	136
Total	419	606	70	49	119	1514
Mean	34·9	50·5	5·8	4·1	9·9	126·2

The cost of grafts by this method worked out Re. 0-13-2 each, the batch raised in June being the cheapest (Re. 0-6-5) and the average cost during the pre-monsoon period between February and June being Re. 0-8-4.

Modified method—using Alkathene wrappers for grafting

The results of the trial as described above but with the rootstock seedlings packed in Alkathene, 100-gauge film, conducted over a six month period from August ,1955 to October, 1955 and March, 1956 to May, 1956 are given in Table II.

TABLE II

Result of trial with rootstock seedlings packed in Alkathene

Period	No. of shoots worked	No. of grafts obtained successfully	No. of layers obtained successfully
1955—			
August	10	3	1
September	10	3	0
October	10	2	0
1956—			
March	10	9	7
April	10	6	2 Main branch was damaged in May 1956
May	10	6	6

The above results indicate that the method can be adopted with advantage during the pre-monsoon period from March to May when the results have been higher than under the normal method without the use of the Alkathene film. The cost of production during this period was found to be less by two to three annas per graft than under the conventional method.

The third modification of the trial attempted in March, April and May, 1956 with the rootstocks packed in Alkathene film but in which the air-layering and grafting were done simultaneously without the interval of four weeks allowed in the original method, gave the following results.

Air-layering and grafting simultaneously

Period	No. done	No. of grafts successful	No. of layers successful
1956—			
March	10	6	6
April	10	6	1 Main branch was damaged in May 1956
May	10	6	7

It is seen from the above data that layering and grafting may be done simultaneously without any adverse effects either on the graft union or on the rooting of shoots. On the other hand, the method was found to result in the earlier separation of the graft and layer by 15 days.

Discussion

The nurse-grafted Y-cutting method was devised by Robinson primarily with a view to root cuttings of citrus species some of which were normally difficult to be so propagated. The success in rooting such cuttings was attributed to the 'trap-action' involved in the method by which by accumulation of growth substances at the ringed portion occurred as a result of the downward flow of synthesised substances from the terminal portions of the shoots which instead of passing into the grafted limb, made their way towards the ringed shoot or the free limb. In addition to this accumulation, the nurse-graft was also believed to aid the translocation of substances to the ringed portion through a N-shaped course, resulting in the rooting. In cashew, there was no difficulty in obtaining own rooted clonal progenies. Air-layering by itself was capable of being employed as a suitable method for commercial production. The combination of this method and grafting, viz. the nurse grafted Y-cutting method, has proved beneficial in the sense that the terminal Y-shaped shoots could be utilised with better advantage to produce a larger number of clones within a short period, one on its own roots and the other on a chosen rootstock with minimum loss of scion material. It may be said that these operations could be done with equal facility without any need for a combination but the results reported in the paper show that the layered portion roots earlier under this method substantiating the theory of the 'trap-action' explained by Swingle *et al*[5].

The utility of Alkathene film as wrappers for rootstocks particularly during the pre-monsoon season from March to May, 1956, has been brought out, resulting in a substantial reduction in the cost of grafts.

It has also been observed that the operations of air-layering and grafting can be done simultaneously without an interval of about four weeks recommended by Swingle *et al.*[5], possibly indicating that the inherent capacity for rooting in cashew may permit this step.

Summary

Vegetative propagation of cashew by the nurse grafted Y-cutting method which is a combination of air-layering and inarching has been described. It was found that this method could be successfully employed for producing a graft and a layer simultaneously from the same shoot. The period between February and May was found to give better results, yielding as many as 10 grafts and 10 layers from 10 shoots worked in February, 1955. Alkathene film as a wrapper over rootstock seedlings was successfully employed, the results being as high as under the trials without the film, and with a substantial reduction in the cost of production.

Acknowledgement

The authors are grateful to Shri U. Narasinga Rao, Horticulturist and Professor of Horticulture, Agricultural College and Research Institute, Coimbatore for suggesting and designing the trials and for his guidance in their conduct. The work was undertaken at the Central Cashew Research Station, Mangalore, under the scheme for research on cashewnut financed partly by the Indian Council of Agricultural Research.

REFERENCES

1. Madhava Rao, V. N. (1956). Studies on vegetative propagation of cashew—(*Anacardium occidentale* L.) 1. Air-layering by cincturing and etiolation of shoots—(In press).
2. ———————— (1956). Multiply the better yielding cashewnut—*Indian Fmg.* **6**, No. 3. pp. 15-17
3. Madhava Rao, V. N. and I. K. Sambashiva Rao (1956). Studies on the vegetative propagation of cashew—2. Approach grafting (inarching) with and without the aid of plastic film wrappers (In Press).
4. Oliver, G. W. (1911). The seedling inarch and nurse plant method of propagation.—*U.S. Dept. Agri. Bur. Pl. Industry, Bull.* 201, 8th series
5. Swingle, T., Robinson, T. R. and May, E. (1929). The nurse grafted Y-cutting method of plant propagation, *J. Heredity*, **20**, 79-94

ACCUMULATION AND MOVEMENT OF MINERALS IN 'BAJRI' (*PENNISETUM TYPHOIDEUM*)

By B. V. Mehta and C. C. Shah, Institute of Agriculture, Anand (Bombay)

[Received for publication on March, 2, 1955
Accepted for publication on January 23, 1958]

LITTLE information is available on the rate of growth and migration of minerals in *bajri*, an important cereal crop of the Kaira district. The present study deals with the assimilation and movement of some macronutrients at important stages in the growth of *kharif bajri* crop.

Methods and materials

Bajri (207) was grown in rows 15 in. apart with plants spaced at about 2 in. within the row in a field of 150 ft. by 100 ft. in area. The previous crop was tobacco, a standard rotation followed here. After every eight rows of *bajri*, there was a row of *tur* (*Cajanus cajan*), this being the common practice here. One row of *bajri* adjoining the *tur* line on each side was left out to avoid the effect of this leguminous plant. Out of the remaining six rows of *bajri*, every alternate row was left out as a guard row to provide normal competition, i.e. samples were taken from the second, fourth and sixth rows. Three such blocks were chosen at random in the field. Each row of 150 ft. length was divided into 5 almost equal units. From each unit in a row, the first five plants were left out and samples collected by random drawing from each unit. In this manner, samples were collected from all the three rows in each of the three blocks and mixed. Samples were collected at growth stage (30 days after sowing), pre-flowering stage (45 days after sowing), milk stage (60 days after sowing), dough stage (75 days after sowing) and harvest stage (90 days after sowing), when the average heights of the plants were 20, 41, 56 and 58 inches respectively. A number of plants (varying according to the size of the plants from 25 to 200) were carefully removed with a shovel, keeping as much soil adhering to the roots as was practicable. In spite of these precautions, the roots of the later samples suffered some damage on account of hardness of clods formed around them. Possibly some fine rootlets were lost in most cases, but the losses in earlier samples were negligible. The soil adhering to the roots was carefully washed out. When the plants were small, only the leafy portion was separated from the roots, but at the pre-flowering stage, the leaves were removed from the stem leaving the sheath with it. At the advent of the milk stage, the ear was separated from the stem, but it was not possible to isolate the grain. At the dough and harvest stages, the grain was separated from the ear. After sorting out each kind of tissue, it was cut into small pieces and a representative sub-sample of 100 gm. wherever available, or the whole sample when the weight was less, was dried to a constant weight at 70°C, and kept in a stoppered

bottle for analysis. Nitrogen was determined by the Kjeldahl procedure, phosphorus and calcium by the A.O.A.C. [1945] volumetric method, potassium by following the volumetric cobaltrinitrite method of Volk and Truog [1934] revised later by Volk [1941] after ashing the plant material, and magnesium by volumetric method of Hardin and MacIntire [1949].

Results and Discussion

Total dry matter

The dry matter data are given in Table I. The rate of production of dry matter was the highest between the milk and dough stages. The highest increase in the weight of the leaf occurred between the pre-flowering and milk stages, that of the stem and root between the milk and dough stages and that of the grain between the dough and the harvest stages.

Table I

Weight (in g.m.) of dry matter per bajri *plant*

Stage	No. of days of growth	Leaf	Stem	Root	Grain	Ear (empty)	Total
Growth	30	0·59	..	0·06	..	..	0·65
Pre-flowering	45	1·34	1·70	0·29	..	..	3·33
Milk	60	2·37	3·94	0·43	..	2·80	9·54
Dough	75	3·00	6·70	1·00	4·30	2·60	17·60
Harvest	90	3·00	6·30	0·83	6·43	2·37	18·93

Accumulation of potassium

Table II shows that the leaf, stem, root and grain have a continuously decreasing percentage of potassium up to the harvest stage, the rate of fall diminishing towards the harvest stage. The stem of the *bajri* plant contains the largest percentage of potassium ; next in order come the leaf, root, empty ear and grain. Only towards the dough and harvest stages, the root is slightly richer than the leaf.

The percentage composition is important, but in studying the assimilation of nutrients by a plant, the total quantities of the constituents present at different stages are more important. In fixing the quantities and the number of doses of the fertilizer, it is essential to find out (1) the stage in the life of the plant up to which the plant continues to assimilate, (2) the stage at which the highest assimilation takes place and (3) the total amount of the minerals which the crop requires. Hence the amount of potassium per plant has been calculated. While the percentage of potassium decreases in the leaf, the per plant amount of potassium in the leaf actually increases up to the harvest stage. In the stem, root and empty ear, there is an increase up to the dough stage and then there is a decline. It is also clear that the stem takes up the maximum amount of potassium. The plant as a whole increases in its potassium content up to the dough stage. After the dough stage, the plant as a whole loses potassium. The plant uniformly takes up this element during three stages of growth, pre-flowering, milk and dough.

Table II

Percentage and weight (in gm.) per bajri *plant of potassium on dry weight basis*

Stage	No. of days of growth	Percentage of potassium					gm. of potassium per plant					
		Leaf	Stem	Root	Grain	Ear (empty)	Leaf	Stem	Root	Grain	Ear (empty)	Total
Growth	30	4·636	..	2·363	..	..	0·0274	..	0·0015	..	..	0·0289*
Pre-flowering	45	2·933	4·363	2·097	..	..	0·0393	0·0741	0·0061	..	..	0 1195
Milk	60	2·211	3·236	1·739	..	0·812	0·0524	0·1288	0·0075	..	0·0227	0·2114
Dough	75	1·593	2·654	1·679	0·551	1·454	0·0477	0·1776	0·0168	0·0237	0·0357	0·3015.
Harvest	90	1·297	2·001	1·551	0·484	1·406	0·0389	0·1260	0·0129	0·0311	0·0333	0·2422

TABLE III

Percentage and weight (in gm.) per bajri *plant of calcium on dry weight basis*

Stage	No. of days of growth	Percentage of calcium					gm. of calcium per plant					
		Leaf	Stem	Root	Grain	Ear (empty)	Leaf	Stem	Root	Grain	Ear (empty)	Total
Growth	30	0·634	..	0·374	..	..	0·0037	..	0·0002	..	..	0·0039
Pre-flowering	45	0·816	0·298	0·288	..	..	0·0109	0·0051	0·0008	..	..	0·0168
Milk	60	0·845	0·266	0·362	..	0·227	0·0200	0·0105	0·0016	..	0·0064	0·0385
Dough	75	0·819	0·246	0·205	0·122	0·173	0·0246	0·0165	0·0021	0·0052	0·0045	0·0529
Harvest	90	0·794	0·202	0·227	0·083	0·202	0·0238	0·0127	0·0019	0·0053	0·0048	0·0485

Accumulation of calcium

The percentage calcium content of the leaf increases up to the pre-flowering stage and it does not materially alter after this stage (Table III). It is highest in the stem at the pre-flowering stage ; then it decreases till harvest. In the root, the percentage is highest at the growth stage, while in the grain it is higher at the dough stage than at the harvest stage.

The per plant weight of calcium is highest at the dough stage in the stem. The grain, root and leaf have almost equal weights of calcium at the dough and harvest stages and these weights are the highest attained. This shows that with the gain in carbohydrate of the grain, there is no gain in the calcium content. All the calcium needed by the grain is absorbed at the dough stage and is redistributed in the grain as it matures. The plant as a whole accumulates calcium up to the dough stage.

Accumulation of magnesium

The percentage of magnesium (Table IV) is highest at the harvest stage in the leaf and empty ear at the pre-flowering stage in the stem and at the growth stage in the root. The grain has a higher percentage at the dough stage than at the harvest stage. After the growth stage, the percentage of magnesium in the leaf is stationary up to the pre-flowering stage but in the next stage there is an increase. At the dough stage, the percentage falls, apparently due to the requirement of other developing tissues, but at the harvest stage the percentage again increases. In the stem, root and grain, after the initial stage the percentage of magnesium decreases but the decrease is never made up during the subsequent stages.

The per plant amount of magnesium is highest at the harvest stage in the leaf, grain and empty ear and it is highest at the dough stage in the stem. In the root there is no difference between the dough and harvest stages. The plant as a whole derives most its magnesium requirement up to the dough stage, the maximum rate of accumulation occurring between the milk and dough stages.

Accumulation of nitrogen

The percentage of nitrogen (Table V) in the leaf increases till the pre-flowering stage. But the per plant amount of nitrogen in the leaf increases up to the milk stage. Then the amount of nitrogen falls, obviously due to the heavy demands of the newly developing ear. After the dough stage, there is practically no change, showing that the requirement of the developing ear is amply met with. The maximum assimilation in the leaf takes place between growth and pre-flowering stages.

The percentage of nitrogen in the stem is highest at the pre-flowering stage. Then it falls up to the dough stage, after which there is an increase. The amount of nitrogen in the stem per plant is highest at the harvest stage. The percentage of nitrogen in the root is highest at the growth stage, but the per plant amount of nitrogen in the roots is minimum at the growth stage and maximum at the harvest stage. Greatest assimilation in the root occurs between the growth and pre-flowering stages.

TABLE IV

Percentage and weight (in gm.) per bajri *plant of magnesium on dry weight basis*

Stage	No. of days of growth	Percentage of magnesium					gm. of magnesium per plant					
		Leaf	Stem	Root	Grain	Ear (empty)	Leaf	Stem	Root	Grain	Ear (empty)	Total
Growth	30	0·251	..	0·200	..	..	0·0015	..	0·0001	..	..	0·0016
Pre-flowering	45	0·247	0·260	0·193	..	..	0·0033	0·0044	0·0006	..	..	0·0073
Milk	60	0·317	0·122	0·162	..	0·083	0·0075	0·0048	0·0007	..	0·0023	0·0153
Dough	75	0·279	0·169	0·158	0·100	0·092	0·0084	0·0113	0·0016	0·0043	0·0024	0·0280
Harvest	90	0·349	0·141	0·175	0·082	0·129	0·0105	0·0089	0·0015	0·0052	0·0031	0·0292

Table V

Percentage and weight (in gm.) per bajri *plant of nitrogen on dry weight basis*

Stage	No. of days of growth	Percentage of nitrogen					gm. of nitrogen per plant					
		Leaf	Stem	Root	Grain	Ear (empty)	Leaf	Stem	Root	Grain	Ear (empty)	Total
Growth	30	1·831	..	1·010	..	..	0·0114	..	0·0006	..	..	0·0120
Pre-flowering	45	2·400	1·192	0·940	..	..	0·0322	0·0202	0·0027	..	..	0·0551
Milk	60	1·841	0·500	0·530	..	1·402	0·0430	0·0195	0·0022	..	0·0392	0·1039
Dough	75	1·192	0·300	0·351	1·65	1·111	0·0357	0·0202	0·0035	0·0707	0·0288	0·1589
Harvest	90	1·221	0·361	0·502	1·90	1·021	0·0365	0·0225	0·0041	0·1224	0·0242	0·2097

TABLE VI

Percentage and weight (in gm.) per bajri *plant of phosphorus on dry weight basis*

Stage	No. of days of growth	Percentage of P_2O_5					gm. of P_2O_5 per plant					Total
		Leaf	Stem	Root	Grain	Ear (empty)	Leaf	Stem	Root	Grain	Ear (empty)	
Growth	30	1·671	..	1·010	..	..	0·0098	..	0·0006	..	..	0·0104
Pre-flowering	45	1·331	1·304	0·690	..	..	0·0178	0·0222	0·0020	..	..	0·0420
Milk	60	1·035	0·893	0·600	..	1·011	0·0245	0·0352	0·0026	..	0·0283	0·0906
Dough	75	0·961	0·936	0·670	1·110	0·694	0·0288	0·0627	0·0067	0·0477	0·0180	0·1639
Harvest	90	0·998	0·701	0·601	1·180	0·657	0·0299	0·0442	0·0050	0·0758	0·0156	0·1705

The percentage as well as the weight of nitrogen per plant in the grain is higher at the harvest stage than at the dough stage. The demand of nitrogen by the *bajri* plant as a whole is greatest between the milk and dough stages and least between the growth and preflowering stages.

Accumulation of phosphorus

The percentage of phosphorus (Table VI) expressed as P_2O_5, is highest in the leaf of the one-month old plant. It then steadily declines up to the dough stage. But reverse is the case with the amount of phosphorus per plant in the leaf. The percentage of phosphorus in the stem is highest at the preflowering stage and lowest at the harvest stage, but the per plant quantity in the stem increases up to the dough stage but falls thereafter. Like phosphorus in the stem, the per plant amount in the root increases up to the dough stage and decreases thereafter. The grain at harvest time has a higher percentage as well as per plant amount of phosphorus than at the dough stage. The plant as a whole has a maximum demand of phosphorus between the milk and dough stages.

Accumulation of dry matter and nutrients

TABLE VII

Total accumulation (in lb.) per acre in bajri

(*Dry weight basis*)

Stage	No. of days of growth	Dry matter	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
Growth	30	231	4·05	3·71	10·21	1·40	0·56
Pre-flowering	45	1181	19·52	15·93	42·40	5·90	2·91
Milk	60	3393	37·43	32·20	75·20	13·60	5·46
Dough	75	6026	56·43	58·30	107·90	18·81	8·73
Harvest	90	6733	74·75	60·70	74·61	17·32	8·79

Table VII gives the total accumulation of dry matter and nutrients per acre. During the grand period of development in weight between the milk and dough stages, there is an accumulation of more than one ton of dry matter. This represents heavy carbon assimilation with absorption of about 19 lb. of nitrogen, 26 lb. of phosphorus (P_2O_5), 33 lb. of potassium, 5 lb. of calcium and 3 lb. of magnesium. The total dry matter per acre is about 3 tons which requires about 75 lb. of nitrogen, 61 lb. of P_2O_5, 88 lb. of potassium, 17 lb. of calcium and 9 lb. of magnesium.

Cation content and ratio

Potassium-ion concentration expressed in m.e. per 100 gm. (Table VIII) in any tissue is greater than that of calcium or magnesium-ions at the corresponding stage of development. The total cation content of the leaf is higher than that of any other organ, the only exception to this being the stem at the preflowering stage. In the

TABLE VIII

Cation Content of bajri *tissues at various stages of growth (in m. e. per 100 gm.) oven-dry weight*

Stage	No. of days of growth	Leaf				Stem				Root				Grain				Empty ear			
		K	Ca	Mg	Total	K	Ca	Mg	Total	K	Ca	Mg	Total	K	Ca	Mg	Total	K	Ca	Mg	Total
Growth	30	119·0	31·7	21·0	171·7	..	..	..	..	61·0	18·7	17·0	96·7	..	..	..	..	..	..	..	..
Pre-flowering	45	75·0	40·8	20·6	136·4	112·0	14·9	21·7	148·6	54·0	14·4	16·1	84·5	..	..	..	..	..	..	..	..
Milk	60	57·0	42·3	26·4	125·7	84·0	13·3	10·2	107·5	45·0	18·1	13·5	76·6	..	..	..	..	21·0	11·4	6·9	39·3
Dough	75	41·0	41·0	23·3	105·3	68·0	12·3	14·1	94·4	43·0	10·3	13·2	66·5	11·8	6·1	10·0	27·9	37·0	8·7	7·7	53·4
Harvest	90	33·0	39·7	29·0	101·7	51·0	10·1	11·8	72·9	40·1	11·4	14·6	66·1	12·1	4·3	6·8	23·2	36·0	10·1	10·8	56·9

leaf, stem, root and grain, the total cation concentration decreases as the plant develops, but in the empty ear it increases, showing translocation of cations to the empty earhead.

For understanding the cation status of the plant, the study of the cationic ratio is important. [Lucas and Scarseth, 1947]. The ratio $\frac{Ca+Mg}{K}$ (Table IX) is not constant in the different parts of the plant. In the leaf, stem root and empty earhead, it widens as the plant develops but in the grain it narrows down. Further, the ratio for the stem is lowest and for the leaf highest at all stages of growth. It can be said that potassium-ions have a more dominant role in the growth of stem and calcium and magnesium-ions have a more dominant role in the growth of the leaf.

TABLE IX

$\frac{Ca+Mg}{K}$ *in equivalents in* bajri *tissues*

Stage	No. of days of growth	Leaf	Stem	Root	Grain	Empty ear
Growth	30	0·44	..	0·58	..	..
Pre-flowering	45	0·82	0·33	0·57	..	..
Milk	60	1·21	0·28	0·70	..	0·87
Dough	75	1·57	0·39	0·55	31·16	0·44
Harvest	90	2·08	0·43	0·82	0·92	0·58

Translocation of the elements during growth

To study the movement of the elements in the different tissues of the plant the period between the dough and harvest stages has been chosen (Table X). It is found that the grain gains, while the leaf, stem, root and empty ear lose potassium, showing that it migrates from these tissues to the grain. But the grain gains only 0·0074 gm. potassium per plant while the rest of the organs lose 0·0667 gm., an amount about nine times the gain by the grain. The plant as a whole loses 0·0593 gm. potassium. This behaviour of potassium is striking but is not abnormal. Similar observations have been made by other workers. Deleano *et al.* [1932, 1933, 1936] have shown that the total amount of potassium in the aerial parts of cereals and tobacco decreases towards the end of their growing season. Bossie [1934], Woodford and McCalla [1936] and Miller [1939] working on wheat, Burd [1919] working on barley, Sayre [1948] working on corn, and Saharsrabuddhe [1928] working on rice, have also made similar observations. Knowles and Watkin [1931] have shown that at maturity, loss of potassium does take place and that such a loss cannot be accounted for by mechanical loss of plant parts or by leaching by rain.

In the case of calcium, the grain and empty earhead together gain while the rest of the organs lose in weight. The plant as a whole loses 0·0044 gm. calcium. As in the case of potassium, it is likely that it passes back into the soil.

TABLE X

Balance account of potassium, calcium, magnesium, nitrogen and phosphorus in the tissues of the bajri *plant (weight in gm. per plant)*

Element	Date and Stage	Grain	Leaf	Stem	Root	Empty ear	Total
Potassium	Oct. 7 dough	0·0237	0·0477	0·1776	0·0168	0·0357	0·3015
	Oct. 22 harvest	0·0311	0·0389	0·1260	0·0129	0·0333	0·2422
	Gain or loss	+0·0074	—0·0088	—0·0516	—0·0039	—0·0024	—0·0593
Calcium	Oct. 7 dough	0·0052	0·0246	0·0165	0·0021	0·0045	0·0529
	Oct. 22 harvest	0·0053	0·0238	0·0127	0·0019	0·0048	0·0485
	Gain or loss	+0·0001	—0·0008	—0·0038	—0·0002	+0·0003	—0·0044
Magnesium	Oct. 7 dough	0·0043	0·0084	0·0113	0·0016	0·0024	0·0280
	Oct. 22 harvest	0·0052	0·0105	0·0089	0·0015	0·0031	0·0292
	Gain or loss	+0·0009	+0·0021	—0·0024	—0·0001	+0·0007	+0·0012
Nitrogen	Oct. 7 dough	0·0707	0·0357	0·0202	0·0035	0·0288	0·1589
	Oct. 22 harvest	0·1224	0·0365	0·0225	0·0041	0·0242	0·2097
	Gain or loss	+0·0517	+0·0008	+0·0023	+0·0006	—0·0046	+0·0508
Phosphorus	Oct. 7 dough	0·0477	0·0288	0·0627	0·0067	0·0180	0·1639
	Oct. 22 harvest	0·0758	0·0299	0·0442	0·0050	0·0156	0·1705
	Gain or loss	+0·0281	+0·0011	—0·0185	—0·0017	—0·0024	+0·0066

Bossie [*loc. cit.*] and Knowles and Watkin [*loc. cit.*] have also found that a loss occurs in calcium in wheat at maturity. Magnesium differs from calcium and potassium inasmuch as the plant as a whole gains 0·0012 gm.

The behaviour of nitrogen is similar to that of magnesium. The grain gains 0·0517 gm. while the leaf, stem and root together gain 0·0037 gm. Only the empty ear loses 0·0046 gm. The plant as a whole gains 0·0508 gm. nitrogen. This means that though a considerable amount of nitrogen migrates in the direction of the grain as it matures, there is no loss in any other tissue except the empty ear, the amount transported being more than replenished by the nitrogen drawn from the soil.

The gain in the amount of phosphorus (P_2O_5) by the grain is about 55 per cent of that of nitrogen. The leaf also gains 0·0011 gm. P_2O_5. The total gain is 0·0292. The remaining three tissues together lose 0·0226 gm. P_2O_5 due to its translocation into the developing grain but the plant as a whole gains 0·0066 gm. by drawing in phosphorus from the soil.

Summary

1. Maximum assimilation of nitrogen, phosphorus and magnesium by the *tajri* plant takes place between the milk and dough stages, while that of calcium between the preflowering and milk stages. Almost continuous and steady absorption of potassium takes place during the three periods of growth preceding the dough stage, but after that the plant seems to return a portion back to the soil. A similar tendency is observed in the case of calcium also. At all stages of growth, the percentage of potassium is greater in the stem than in other parts, while that of calcium and magnesium is higher in the leaf than in others. The grain is richer in nitrogen and phosphorus than the rest of the organs.

Acknowledgement

The authors express their gratefulness to Dr. M. D. Patel, Director, Institute of Agriculture, Anand, for his help and encouragement and to Prof. C. J. Patel, Assistant Professor of Agronomy, for giving facilities in field work.

REFERENCES

A. O. A. C., 6th Ed. (1945).
Bossie, V. G. (1934). Inst. Arte. Grafice. Ed. Marvan. *Principle Mucea.* **10**, 1-84
Burd, J. S. (1919). *J. Agric. Res.* **18**, 51-72
Deleano, N. T. *et al.* (1932). *Bio. d. Pflanz.* **19.** 249
—— (1933). *Ibid.* **20** : 179
—— (1936). *Ibid.* **24** : 19
Hardin, L. J. and MacIntire, W. H. (1949). *J. A. O. A. C.* **32.** 139
Knowles, F. and Watkin, J. E. (1931). *J. Agric. Sci.* **21.** 621-637
Lucas, R. E. and Scarseth, G. D. (1947). *J. Amer. Soc. Agron.* **39.** 887-896
Miller, E. C. (1939). *Kansas Agric. Exp. Sta. Tech. Bull. No.* **47**
Sahasrabuddhe, D. L. (1938), *Agric. Dept. Bombay Bull. No.* **154**
Sayre, J. D. (1948). *Plant. Physiol,* **23.** 267-281
Volk, N. J. (1941). *J. Amer. Soc. Agron.* **33.** 684-689
J. and Truog, E. (1934). *Ibid.* **26.** 537-546
Woodford, E. K. and Mc. Calla, A. G. (1936). *Canadian J. Res.* **140.** 245

A STUDY ON FODDERS OF HISSAR DISTRICT IN THE PUNJAB

By B. M. Patel, B. G. Shah and V. V. Mistry, Institute of Agriculture, Anand (Bombay)

[Received for publication on September 17, 1957
Accepted for publication on January 15, 1958]

An animal nutrition survey was undertaken in Hissar district with a view to ascertain the prevailing feeding conditions there. The total area of the district is 3,514,392 acres, out of which 2,148,982 acres are cultivated. The crops grown in the area are given below with their acreages:

Crop	Acreage	Crop	Acreage
Bajri	1,044,017	*Taramira*	20,000
Gram	577,081	Paddy	17,975
Jowar	141,959	Vegetables	3,598
Wheat	141,660	Maize	2,858
Cotton	49,926	*Til*	1,947
Sugarcane	44,984	Oats	629
Rape	44,000	Other fodders	2,337
Barley	33,011		

By-products of these crops are naturally available as fodders for cattle and some of them are used as concentrates. Moreover, grazing is also available in monsoon and winter.

Amongst the crops grown, *guar* (*Cyamopsis psoraliorides*), *jowar* (*Andropogon sorghum*), *bajri* (*Pennisetum typhoideum*) are the main *kharif* crops, and wheat, barley, oat and gram are important *rabi* crops. Among cultivated fodders, lucerne and berseem are grown by some farmers. Wheat-chaff and gram *bhusa* (outer pod coverings, thin stems and leaves), which are the by-products of agriculture are fed to cattle. Moreover, leaves of *babul* (*Acacia arabica*) are used for feeding sheep and goats and leaves of *neem* (*Melia azadirachta*) and *shisham* (*Dalbergia sissoo*) are important as scarcity fodders.

Experimental

(a) *Method of sample collection.* The area within about 12 mile radius from Hissar was divided into four quadrants. The villages in each quadrant were listed separately and one village was selected at random from each quadrant. Each

village was divided into four blocks and samples were taken from several places in each block. All the material from four blocks was mixed and a composite sample was taken to represent the village. The samples were chaffed and milled into powder before analysis.

(b) *Methods of analysis.* A.O.A.C. [1950] methods of analysis were followed.

Results and discussion

The results in Table I will show that the differences between the nutrients of the fodders are highly significant except in the case of ether extract and phosphorus.

Table I

Composition of some kharif *crops of Hissar area*

(*Average of four results*)

Fodder	Age in months	C. protein	E. Ext.	N. F. E.	C. fibre	Phosphorus	Calcium
Guar	2	18·70	1·82	41·52	21·05	0·30	2·49
	3	12·81	1·51	49·25	29·52	0·26	0·71
Jowar	2	6·64	2·23	49·18	31·31	0·24	0·53
	3	4·62	1·81	56·10	31·15	0·22	0·32
Bajri	2	10·88	2·24	40·73	28·52	0·31	0·65
	3	5·29	1·54	47·58	33·16	0·28	0·50
Fodders		42·03**	2·52	9·34**	10·32**	1·75	70·56**
Cuts		22·26**	13·20**	17·11**	13·06**	0·91	65·63**
Fodders × cuts		1·74	0·78	0·03	4·37*	0·08	36·84**
Villages		0·36	0·32	6·18**	5·88**	0·17	2·10

* Significant at 5 per cent level. ** Significant at 1 per cent level.

The composition of different cuttings shows that there is a decreasing trend in protein, ether extract and calcium, while crude fibre and N.F.E. increase with

maturity. The change in phosphorus, however, is not significant. The protein content in *bajri* fodder is reduced to the extent of 50 per cent, while in *jowar* and *guar* fodders the reduction is about 33 per cent. With regard to the fibre content, *guar* becomes more fibrous, while there is least variation in the fibre content of *jowar* fodder. The calcium content of *guar* in the young stage is more than three times that in the mature stage, while the decrease in cereal fodders is only about 25 per cent from the young stage to the mature one.

The interaction between fodders and cuts is found to be significant in the case of crude fibre and calcium which means that the extent of change due to maturity in these nutrients varies from fodder to fodder. This confirms the above observations regarding variation in these nutrients due to maturity of *guar* as compared to other fodders.

The samples collected from different villages are similar in composition except that the crude fibre content of samples from Raipur is higher and hence N.F.E. lower than that of samples from other villages. This may be due to a little early sowing in Raipur.

The data in Table II will show that the composition of the fodder with respect to all the nutrients varies significantly with the stage of growth. The first cutting differs considerably from the later cuttings, while the second and the third cuttings

TABLE II

Composition of wheat fodder

(*Average of four results*)

Period of growth (in months)	C. protein	E. extract	N. F. E.	C. fibre	Phosphorus	Calcium
1	15·01	2·86	41·52	19·68	0·36	0·52
2	5·20	1·94	49·58	33·02	0·16	0·27
3	2·90	2·22	51·72	35·13	0·12	0·27
F Value ; Villages	1·03	0·98	3·31	2·46	0·42	0·21
Stages	15·32**	8·27*	5·07†	22·20**	10·47*	18·42**
C. D. for stages at 5 per cent level	5·67	0·57	8·27	6·16	0·14	0·11

* Significant at 5 per cent level.
** Significant at 1 per cent level.
† Approaches significance at 5 per cent level.

do not differ to that extent. A decreasing trend with maturity is observed in crude protein, phosphorus and calcium contents and an increasing trend in crude fibre and N.F.E. It is remarkable that the crude protein content in the first cutting is as high as 15 per cent and drops down to one-third in the second cutting.

The general observations on the trend of variations in the composition of barley fodder are similar to those made in the case of wheat fodder. However, in the case of crude fibre it is found that it is maximum in the second cutting and decreases slightly in the third cutting. It may be noted that phosphorus content in the fodder from different villages varies significantly. The average phosphorus content of the three stages for the fodder from Raipur (0·39 per cent) is about 80 per cent higher than those for the fodder from Malapur (0·25 per cent), Manghali (0·20 per cent) and Satrod (0·22 per cent).

TABLE III

Composition of barley fodder

(*Average of four results*)

Period of growth (in months)	C. protein	E. extract	N. F. E.	C. fibre	Phosphorus	Calcium
1	15·75	3·13	45·04	19·10	0·37	0·84
2	6·56	2·40	49·42	31·07	0·24	0·52
3	5·43	2·53	57·26	27·03	0·18	0·47
F Value :						
Villages	0·98	0·16	0·89	2·60	13·48**	4·00
Stages	16·76**	7·47*	5·24*	94·72**	22·02**	20·18**
C. D. for stages at 5 per cent level	4·77	0·48	9·34	2·14	0·07	0·15

* Significant at 5 per cent level.
** Significant at 1 per cent level.
* Approaches significance at 5 per cent level.

A perusal of Table IV will reveal that in oat fodder the change in the composition with maturity is similar to that observed in wheat and barley fodder.

From the critical differences it is evident that wheat straw is poorer than other straw in all the nutrients except phosphorus and that barley and oat straws are similar in composition except that oat straw is significantly richer in ether extract.

TABLE IV

Composition of oat fodder

(Average of four results)

Period of growth (in months)	C. protein	E. extract	N. F. E.	C. fibre	Phosphorus	Calcium
1	18·81	3·63	37·51	18·00	0·39	0·73
3	5·26	3·45	55·86	27·34	0·16	0·43
F Value :						
Villages	1·05	1·73	0·54	0·15	1·87	0·44
Stages	8·28	0·10	7·60	64·46*	8·13	12·86
C. D. for stages at 5 per cent level	20·25	2·42	28·58	4·99	0·34	0·36

* Significant at 5 per cent level.

(N.B.—The samples of the second cutting were damaged in transit and could not be analysed.)

Comparison of wheat, barley and oat straws

Straw	C. protein	E. extract	N. F. E.	C. fibre	Phosphorus	Calcium
Wheat	2·90	2·22	51·72	35·13	0·12	0·27
Barley	5·43	2.53	57·26	27·03	0·18	0·47
Oat	5·26	3·45	55.86	27·34	0·16	0·43
F Value	18·56**	11·58**	3·32	30·22**	1·54	4·39
C. D. at 5 per cent level	1·14	0·66	5·47	2·91	0·10	0·18

** Significant at 1 per cent level.

The data in Table V show significant differences between cuttings of berseem in crude protein, N.F.E. and crude fibre. The crude protein decreases in the third cutting to the extent of 30 per cent, while the crude fibre increases by about 50 per cent. N. F. E. decreases by about 15 per cent from the first to the second cutting and again attains the maximum value in the third cutting.

TABLE V

Composition of berseem

(*Average of four results*)

Monthly cuts	C. protein	E. extract	N. F. E.	C. fibre	Phosphorus	Calcium
1	20·06	2·84	42·15	16·06	0·40	1·85
2	21·08	2·92	36·36	17·84	0·52	2·18
3	14·54	3·34	44·83	24·30	0·30	1·80
F Value :						
Villages	1·93	0·16	1·06	2·25	0·94	0·01
Stages	10·82†	0·63	30·68**	25·26	2·12	0·78
C. D. for stages at 5 per cent level	3·70	1·18	2·70	3·01	0·26	0·79

** Significant at 1 per cent level. † Approaches significance at 1 per cent level.

TABLE VI

Composition of lucerne

(*Average of four results*)

Monthly cuts	C. protein	E. extract	N. F. E.	C. fibre	Phosphorus	Calcium
1	24·50	2·57	41·02	16·20	0·42	1·96
2	20·78	3·12	36·10	25·67	0·35	2·24
3	15·97	3·54	40·06	29·74	0·24	1·88
F Value :						
Villages	0.58	0·86	0·49	0·62	0·49	0·42
Stages	11·61**	3·44	2·18	13·53**	1·72	2·42
C. D. for stages at 5 per cent level	4·36	0·91	6·12	6·54	0·25	0·42

** Significant at 1 per cent level.

The crude protein content in lucerne (*vide* Table VI) decreases from the first to the second cutting by about 15 per cent and from the second to the third cutting by about 20 per cent. On the other hand in the case of berseem no significant variation in crude protein is observed between the first two cuts. In the first cutting lucerne is richer than berseem in crude protein by about 20 per cent. The crude fibre in lucerne increases regularly from the first to the third cutting, while in berseem the first two cuts are not found to vary significantly in this respect. The trends of variation in N.F.E. and calcuim contents of lucerne are similar to those observed in berseem and the phosphorus content decreases continuously from the first to the third cutting.

A statistical comparison of the composition of the three cuttings of the two fodders, however, does not bring out any significant differences. On the whole these leguminous fodders are four times richer in calcium than the cereal fodders. The samples of the same fodder from different villages do not vary significantly in any case.

TABLE VII

Composition of wheat chaff

Village	C. protein	E. extract	N. F. E.	C. fibre	Phosphorus	Calcium
V_1	5·55	2·22	54·18	29·25	0·14	0·45
V_2	5·28	2·23	49·22	23·22	0·17	0·55
V_3	5·04	1·94	50·10	30·30	0·16	0·44
V_4	3·44	1·88	52·05	30·91	0·15	0·46
Average	4·83	2·07	51·39	28·42	0·16	0·48
S. E.	0·474	0·092	1·102	1·766	0·006	0·025

The composition of wheat chaff (Table VII) indicates that it is apparently superior in all nutrients to "Niphad" wheat straw grown in Anand area, which has 3·20 per cent crude protein, 1·88 per cent ether extract, 44·92 per cent N.F.E., 35·43 per cent crude fibre, 0·13 per cent phosphorus and 0·36 per cent calcium.

TABLE VIII

Composition of gram bhusa

Village	C. protein	E. extract	N. F. E.	C. fibre	Phosphorus	Calcuim
V_1	4·59	1·64	59·58	34·11	0·07	1·48
V_2	5·58	2·26	51·54	28·42	0·08	1·84
V_3	2·60	1·46	48·87	41·28	0·03	1·02
V_4	3·01	1·59	49·15	37·80	0·04	1·29
Average	3·94	1·74	52·24	35·40	0·06	1·40
S. E.	0·693	0·178	2·510	2·750	0·013	0·172

From the results in Table VIII it is apparent that gram *bhusa* is remarkably rich in calcium like other leguminous fodders. However, the crude protein content is only 3·94 per cent. The composition of this by-product appears to vary considerably from village to village probably because of different proportions of husks and gram particles in the final product.

A comparison of the composition of wheat chaff and gram *bhusa* reveals that the former is significantly richer in phosphorus while the latter is richer in calcium.

The data in Table IX show that crude protein and ether extract contents of the grasses show a decreasing trend with maturity, while the differences in other nutrients are not significant. Phosphorus content also appears to decrease as the grasses grow.

TABLE IX

Composition of grasses

(*Average of three results*)

Grass	C. protein		E. extract		N.F.E.		C. fibre		Phosphorus		Calcium	
Monthly cut No.	1	2	1	2	1	2	1	2	1	2	1	2
Anjan (*Cenchrus montanus*)	11·37	6·37	2·63	1·78	52·21	41·67	20·78	37·37	0·34	0·25	0·38	0·25
Baru (*Sorghum halepaanse*)	10·28	5·11	2·30	1·49	43·34	47·54	35·85	36·44	0·28	0·26	0·38	0·31
Ghamur (*Panicum antidotale*)	13·99	10·42	2·74	1·79	36·42	40·94	34·62	38·54	0·38	0·24	0·38	0·48
Makara (*Eleusine aegyptiaca*)	8·32	7·29	2·46	1·81	40·56	45·66	35·19	34·76	0·32	0·22	0·36	0·47
Samakh (*Panicum colonum*)	9·12	6·71	2·10	2·03	37·28	41·85	36·60	32·12	0·30	0·33	0·62	0·45
Average	10·62	7·18	2·45	1·78	41·96	43·53	32·61	34·85	0·32	0·26	0·42	0·39
't' value	4·41*		4·19*		0·52		0·61		2·13		0·55	

TABLE X

Composition of tree leaves

(Average of four results)

Nutrients	*Babul (Acacia arabica)*		*Neem (Melia azadirachta)*		*Shisham (Dalbegia sissoo)*	
	AV	S.E.	AV	S.E.	AV	S.E.
C. protein	7.04	1.219	15·87	0·100	9·99	0·349
E. extract	2·56	0·328	5·09	0·414	3·10	0·196
N. F. E.	51·16	4·454	50·73	1·175	45·14	3·041
C. fibre	33·32	6·323	17·68	1·162	31·97	3·211
Phosphorus	0·11	0·006	0·24	0·029	0·16	0·010
Calcium	1·24	0·180	0·89	0·089	1·95	0·153

The composition of *babul*, *neem* and *shisham* leaves (Table X) indicates that they can serve as good supplementary fodder, rich in crude protein and calcium. It is worthwhile noting that *neem* leaves are also rich in phosphorus and are considerably lower in crude fibre than other common fodders. The calcium content in the *neem* leaves from Hissar area is about one-third that in the leaves from Anand area reported by Patel and Patel [1957], *shisham* leaves from Hissar area contain only two-thirds the amount of crude protein observed in *shisham* leaves by Momin and Ray [1943]. On comparing the composition of *babul* leaves from Hissar area and from Anand area, it is observed that the former are lower in crude protein, ether extract and minerals by about 50 per cent and higher in crude fibre by about four times than the latter.

REFERENCES

Anon. (1950). (*Official and tentative methods of analysis of the Association of Official Agricultural Chemists 1950*) Seventh Edition, A.O.A.C., Washington, D.C.

Momin, S. A. and Ray, S. C. (1943). *Indian J. vet. Sci.*, **13**. 183.

Patel, B. M. and Patel, P.S. (1957). *Indian J. agric. Sci.* **27**. 307.

DEFICIENCY SYMPTOMS IN *SESAMUM INDICUM* L. (GINGILI)

SYMPTOMS PRODUCED BY DEFICIENCY OF NITROGEN, PHOSPHORUS, POTASSIUM, CALCIUM AND MAGNESIUM

By N. L. Pal and M. Bangarayya, Central Tobacco Research Institute, Rajahmundry, Andhra State

[Received for publication on November 27, 1956
Accepted for publication on January 15, 1957]

(With plates I—V)

THERE are at least 26 elements that are known to be absorbed by the plants. Of these about 16 are considered as essential for normal growth. Lack of some of the elements in the soil or their uptake in insufficient quantities by the plants often cause visible changes in the growth of the plants and results in the distortion or discolouration of the leaves or stems and death of tissues. These symptoms called deficiency symptoms, provide important clues regarding malnutrition of the crops in the fields. It may, however, be noted that deficiency symptoms are merely symptoms and some of them may be produced by other causes such as diseases and pests or toxicity due to various chemicals in the soil or in the atmosphere. In order to be sure about the deficieny of a particular element, therefore, it is desirable to resort to other methods of study such as tissue tests, patholoigcal tests or a chemical examination of the constituents of the plants and the soil in which they are growing. Nevertheless, the apparent symptoms are of great value in diagnostic work and are often the only clues available for correction of the nutritional status of a crop or a field.

The deficiency symptoms are generally of such a nature that descriptive accounts by themselves do not produce a very clear picture but they can be readily recognised if accompanied by coloured illustrations.

Two invaluable books 'Hunger signs in crops' and 'The Diagnosis of Mineral Deficiencies in Plants by Visual symptoms' are indispensable references on this subject and are constantly consulted in the study of problems connected with nutritional disorders in the plants. The numerous coloured plates in the books depicting the symptoms in various crops serve as important guides for diagnostic work in the field. Recently a smaller publication named 'Nutritional disorders of plants' has been issued from Australia, illustrating the deficiency symptoms observed in some crops in Queensland.

The purpose of this paper is to report the deficiency symptoms in *Sesamum indicum* L. (*gingili* or *til*), as the symptoms produced on this plant have not been recorded in other works. The symptoms produced by the lack of nitrogen, phosphorus, potassium, calcium and magnesium are presented.

Methods

Gingili (variety local *Punasa*) was grown in small glazed pots of 5 in. diameter and 6 in. height in sand that was washed with dilute hydrochloric acid and later with distilled water. When the first pair of normal leaves were developed the plants were thinned down to three per pot and nutritional treatments were started. The plants were supplied with a full compliment of nutrients except one in each treatment. The controls received the full compliments of all the elements. Hoaglands [1939] formulae as detailed below were used in preparation of the nutrients.

Control solution	Quantity added in ml./ pot, each week
1 M KH_2PO_4	1
1 M KNO_3	5
1 M $Ca(NO_3)_2 \cdot 4H_2O$	5
1 M $MgSO_4 \cdot 7H_2O$	2
Without Nitrogen—	
0·5 M K_2SO_4	5
1 M $MgSO_4 \cdot 7H_2O$	2
0·05 M $CaH_4(PO_4)_2 \cdot H_2O$	10
0·01 M $CaSO_4$	200
Without Potassium—	
1 M $Ca(NO_3)_2 \cdot 4H_2O$	5
1 M $MgSO_4 \cdot 7H_2O$	2
0·05 M $CaH_4(PO_4)_2 \cdot H_2O$	10
Without Phosphorus—	
1 M $Ca(NO_3)_2 \cdot 4H_2O$	4
1 M KNO_3	6
1 M $MgSO_4 \cdot 7H_2O$	2
Without Calcium—	
1 M KNO_3	5
1 M $MgSO_4 \cdot 7H_2O$	2
1 M KH_2PO_4	1
Without Magnesium—	
1 M $Ca(NO_3)_2 \cdot 4H_2O$	4
1 M KNO_3	6
1 M KH_2PO_4	1
0.5 M K_2SO_4	3

NITROGEN DEFICIENCY

Growth reduced; branching suppressed; leaves erect almost hugging the stem; lower leaves develop a wash of lemon yellow colour which later turns orange. (The pot on the left has two normal plants).

PHOSPHORUS DEFICIENCY

Plants lean and lanky; unable to stand erect in extreme cases; branching reduced; lower leaves develop marginal chlorosis followed by bands of dead tissue.

To each of the above solutions a solution comprising the following minor elements was added at the rate of 1 ml. per litre to provide for the other elements.

	gms./litre
Manganese sulphate	1·0
Boric acid	2·8
Zinc sulphate	0·1
Cupric sulphate	0·1

Iron requirement was met by adding separately 0·5 per cent $FeSO_4$ at 1 ml. per 1 litre.

The nutrients were diluted in water and were applied once a week.

In the case of nitrogen deficient cultures the plants did not grow beyond three pairs of leaves and were extremely stunted and weak ; so much so, that proper symptoms could not be recorded. Such severe deficiency of nitrogen is not likely to arise normally in fields. Hence, in later experiments a small dose of nitrogen was added to the pots in the first week and later the nutrients were drained off by washing with distilled water and the plants were then put on nitrogen deficient treatment.

The following were the symptoms observed in plants growing under deficiencies of the various elements. The accompanying illustrations are reproduced from 35 mm. " Kodachrome transparencies " taken in sunlight.

Nitrogen : The plants are upright, thin, and stunted with little or no branching. The leaves are reduced in size, erect and almost hugging the main axis. Leaves and capsules are few in number. Starting with leaves in the lower position and gradually going up, the leaves develop a lemon yellow colour which changes later to a bright orange colour. Defoliation occurs at this stage.

Phosphorus : The plants are thin and tall with little or no branching. The leaves and capsules are few in number. The lower leaves are dull, lusterless grayish green. The gray colour appears generally at the tip of the lowermost leaves and is followed by small necrotic spots. The necrotic spots coalesce to give bands of dead tissue. At this stage, the plants cannot stand erect and have to be supported. Defoliation occurs only when the dead tissue extends beyond half of the lamina.

Potassium : The plants are dwarfed with normal branching. Number of capsules borne are few. The margins of the lower leaves become first wavy and later cupped up from the tip. Chlorosis occurs in the interveinal areas leaving the veins green thus giving the leaf a chequered appearance. The chlorosis is of light yellow colour which in the later stages changes to orange and finally to coppery brown.

Calcium : The plants are more or less normal in height and number of leaves but the number of capsules is reduced. The symptoms appear first on the matured leaves at the top. Puckered areas appear on either side of the midrib, and the margins are cupped under. Later puckered portions appear pale lemon yellow

in colour. In later stages the young leaves at the top exhibit a typical hooking down of the tips, followed by twisting. Finally, the terminal bud dies. Axillary buds are later developed but, eventually, they also produce similar symptoms and die.

Magnesium : The height of the plant and the number of leaves are not much reduced. The lower leaves develop interveinal chlorosis. The chlorosis is of light lemon yellow colour in the initial stages but later takes an orangish tinge. The green colour persists in the midrib and the veins for some time.

A key to the deficiency symptoms is given below for easy reference.

Key to the deficiency symptoms in gingili due to nitrogen, phosphorus, potassium, calcium and magnesium.

I. *Effects generalised on the whole plant, generally appearing first on the older parts.*

A. *General chlorosis with or without drying up :*

i. Plants light green, stalks slender, branching absent with erect leaves. Lower leaves develop lemon yellow colour turning later to bright orange. Defoliation of yellowed leaves — **Nitrogen**

ii. Branching suppressed ; stalks slender ; lower leaves dull, lusterless grayish green followed by necrosis and defoliation — **Phosphorus**

iii. Lower leaves develop interveinal chlorosis of light lemon yellow colour changing later to orangish tinge. The green colour persists longer on the midrib and veins — **Magnesium**

B. *Chlorosis appearing as mottling with or without necrosis :*

i. Plants dwarfed. Margins of lower leaves become wavy and later cupped up. Light lemon yellow chlorotic mottling appears which later turns to bright orange and finally to coppery brown. No defoliation — **Potassium**

II. *Effects localised in the growing regions :*

A. *Terminal bud dies following distortions of the tip and bases of young leaves :*

i. Hooking down at the tips of top young leaves followed by twisting and puckering. Terminal bud dies — **Calcium**

POTASSIUM DEFICIENCY

Growth dwarfed, branching normal; lower leaves cupped up; intervrinal chlorosis giving a marbled appearance

CALCIUM DEFICIENCY

← Growth reduced ; top leaves hooked downwards followed by twisting ; death of terminal bud.

↓

MAGNESIUM DEFICIENCY

Plants more or less in size; lower ←leaves develop interveinal chlorosis; midrib and main veins remaining green for some time.

↓

ACKNOWLEDGEMENTS

The authors thank Dr. N. R. Bhat, Director, Tobacco Research, for his keen interest in the work and for the facilities provided in the course of the investigations. They are also thankful to the Indian Central Oilseeds Committee for a grant for bearing the cost of the investigations conducted at the Central Tobacco Research Institute, Rajahmundry.

REFERENCES

Hunger Signs in Crops. (1949). *Amer. Soc. Agr. and Nat. Fert. Ass.*, Washington

Wallace, T. (1951). *The Diagnosis of Mineral Deficiencies in plants by Visual Symptoms.* H.M.S.O., London

Von Stieglitz, C. R. and Chippendale, F. (1955). *Nutritional disorders of plants.* Queensland *Dept. Agric. and Stock*, Brisbane, Australia

Hoagland, D. R. and Arnon, D. I. (1939). *The water culture method for growing plants without soil. Cal. Agr. Expt. Sta. Circ.* 347

SOME PROBLEMS OF MARKETING OF CASH CROPS IN KOLHAPUR DISTRICT*

By S. S. Madalgi, University of Bombay, Bombay

[Received for publication on April 20, 1957
Accepted for publication on July 26, 1957]

So far no research has been done in the Marketing of cash crops in the Kolhapur district of Maharashtra. Therefore, the present study may be said to fill the lacuna to some extent. The aim of this study was to assemble the facts about the marketing system, analyse them and locate the problems with a view to suggest some measures for promoting efficient marketing system. The study mainly concentrates on a few major aspects such as marketable surplus, process of marketing, the nature of competition in the markets, the measurement of marketing costs, co-operative marketing and the working of regulated markets. Because of their significance on national scale, the problems of price fluctuations and warehousing have been excluded from the present study.

Kolhapur district is the southernmost part of the Maharashtra region of Bombay State. Most important cash crops grown in the district are sugarcane, tobacco and groundnut which account for 24 per cent, 19 per cent and 5 per cent respectively of the area under these crops in Bombay State. The acreage of these crops in the district has been increasing rapidly since 1900. During the last five decades, area under sugarcane has increased three times, under tobacco two times, groundnuts ten times.

Since these commodities are cash crops, their cultivation is undertaken for sale rather than for personal consumption. Therefore, their marketable surplus is relatively more. In our study of 181 cultivators, it was found that the marketable surplus of *gur* was 90 per cent, of tobacco 99 per cent and of groundnut 54 per cent of the production.

The three factors accounting for the gap between production and marketable surplus were : (1) harvest expenses paid in kind, (2) retention for personal consumption and (3) *baluta* (i.e., payment in kind to village artisans). These factors had varying degrees of impact on marketable surplus in different size groups of production. In the case of *gur* the harvest expenses paid in kind tend to vary directly with output. On the other hand, the other two factors were inversely related with output. The total impact of these factors on the marketable surplus was that on account of the last two factors, a given increase in production was

* Based on the thesis submitted for the Ph.D., degree of the University of Bombay.

accompanied by less than proportionate increase in the marketable surplus. In the case of groundnut, only the second factor was in inverse relation with production and the behaviour of marketable surplus was identical with that of *gur*. In the case of tobacco, practically the entire output was marketed. The data for *gur* are given in Appendix 1.

The marketable surplus arising out of the operation of the factors mentioned above is sold in the marketing centres, namely, Kolhapur, Gadhinglaj, Jaisingpur and Nipani. Of these the first three are in the Kolhapur district and the fourth market is situated a little beyond in the Belgaum district. Kolhapur and Gadhinglaj are famous for *gur* and groundnut and Jaisingpur and Nipani for tobacco. These markets are both assembling and exporting centres. *Gur* and groundnut produced in the whole district is assembled at Kolhapur and Gadhinglaj markets, and of the total quantity of 16 lakh Bengal maunds assembled nearly 93 per cent is exported to various consuming centres. The main centres of consumption for *gur* produced in the district are, Gujarat with 43 per cent of the total quantity assembled, Konkan with 20 per cent, Karnatak 20 per cent, Bombay City and suburbs 10 per cent. The local consumption is only 7 per cent of the total. In the disposal of tobacco exports also occupy the dominant position. For instance, during 1953-54, of the total quantity of 10·7 million lb. assembled in the Jaisingpur market 9·1 million lb. or 86 per cent of the total was exported. Likewise, of the total quantity of 21·6 million lb. assembled in the Nipani market 87 per cent was exported and the remaining quantity was used for local consumption. The main centres of consumption for tobacco from this region are : Madras, Madhya Pradesh, West Bengal and some districts of Bombay Deccan. The data are given in Appendix 2.

These important tasks of assembling and export are carried out by various marketing agencies operating in the market. There are three types of marketing agencies, namely, village traders, commission agents (seller's) and wholesale buyers. The village traders function only in the marketing of *gur* and groundnut. Further, the village traders are found only in the Gadhinglaj taluka and mostly absent in other talukas. The total number of village traders working in the area was 401 in 1948-49, but their strength declined to 187 in 1954-55. Such decline is mainly due to the low turnover of business that they could get to handle. The data collected by us indicate that the average turnover of business was 125 Bengal maunds of groundnut per trader valued at Rs. 2,000 and the average earnings by way of commission were Rs. 300 and in some cases even less than that. Hence was the exodus of traders from this field and decline in their strength.

In the village sales of tobacco there are a few traders. For instance, in the Gadhinglaj taluka the number of village traders was around 25 and the average turnover of business of each trader was of Rs. 15,000 per annum. The main reason for the prevalence of a few traders in this line was the element of risk involved and the oligopsonistic manipulations in the market. On the contrary, the absence of these factors explains the overcrowding in the groundnut trade.

Groundnuts and tobacco thus assembled by the village traders is sent for sale to the commission agents in the marketing centres. The commission agents are, therefore, the second agency which participate in the marketing process. This agency is found in the marketing of all three commodities. However, in the case of tobacco, since this agency rarely does a purely commission agency work and its predominant interest is in trading on own account, we have treated it as wholesale traders. Our study was, therefore, mainly confined to this agency in the Kolhapur and Gadhinglaj markets.

The main functions of commission agents in this market may be put as follows :

(1) acting as a middleman between the buyers and the sellers and

(2) financing the cultivator for cultivation and other purposes.

Sometimes they do many other functions like dealing in commodities, like turmeric, chillies, cotton, fertilizers, storing the farmer's produce until its sale, etc., some of which are ancillary to the main functions.

The number of commission agents operating in the Kolhapur market was stable at 165 during the last 7 years. However, underlying this stability there was entry of many new firms and exodus of old firms. For instance, during the period of 7 years beginning with 1947-48 the total number of firms entering this line of trade was 102 and during the same period the number of firms closed was 103. The main cause which impelled the firms to enter this business was obviously profit motive, whereas the exodus of firms was due to the various factors which stated in order of importance were : (1) the low turnover of business, (2) the loss in secondary business, (3) loss from bad debts and (4) miscellaneous. The significance of the first cause could be seen from the fact that in the Kolhapur market in 1953-54, 39 per cent of commission agents out of 164 had captured 82 per cent of the volume of business in *gur*, leaving only 18 per cent for the remaining 61 per cent firms. The outcome of this situation was that 73 firms out of 161 were on an average earning only Rs. 1,503 by way of commission per year which was barely enough to maintain the firms in business, and there were other 28 firms with average earnings of Rs. 211 per annum only and, therefore, were on the verge of quitting this line of trade.

Practically the same causes were responsible for the failure of firms in the Gadhinglaj market.

An enquiry into the nature of competition in the market was another important aspect of our study. In the markets in the Kolhapur districts the following four factors were particularly important in explaining the nature of competition :

(1) the large number of buyers,

(2) the auction method of sale,

(3) the standardised nature of the product and

(4) the accessibility of market information to buyers and particularly to sellers.

In the markets where all these factors exist, competitive situation would prevail. However, the presence of each one of these factors was not a necessary condition of competition. For instance, in the village sale of groundnut even though sales were effected by private negotiation between the village trader and the farmer—intense competition prevailed on account of the presence of large number of village traders trying to buy the maximum quantity—the close link of villages with the Gadhinglaj market where auction method is practised and the easy accessibility of price information to cultivators. These factors brought the forces of competition which overshadowed the forces of imperfections contained in the sale by ' private negotiation '.

In the village sale of tobacco, however, utter imperfections were found due to the absence of all the factors mentioned above. Particularly, the factors like a few buyers buying tobacco, and the secret method of sale were highly responsible for imperfections in such markets.

In the Kolhapur and Gadhinglaj market competition was maintained by the presence of all the four factors mentioned above. In these markets the marketing of *gur* and groundnut is regulated and it has contributed very much to the competition by enforcing the auction method of sale.

In contrast to these markets, tobacco markets, namely, Nipani and Jaisingpur indicated large imperfections which originated mainly from the absence of all the factors referred to above. In particular, the fact that a few traders buying a substantial portion of tobacco assembled and the sale by private negotiation accentuated the imperfections in these markets. It is significant to note that these imperfections have percolated to village transactions. Data regarding the oligopsonistic situation in Nipani market are given in Appendix 3.

These differences in the nature of competition in these markets explain partly the differences in the cost of marketing of *gur* and groundnut on the one hand and tobacco on the other. Our study indicates that in the village sale of groundnut the share of the producer in the second wholesale price (i.e., the price at which the farmer's produce is sold to wholesale traders in the marketing centres) was about 85 per cent to 88 per cent and 95 per cent in the case of groundnut sold directly in the markets, by-passing the village traders. In the case of *gur* also, the share of the producers was 95 per cent and never declined below that since 1945. Details are given in Appendix 4. On the other hand, in the case of tobacco sold in the villages the share of the producer in the second wholesale price was 40 per cent in the Jaisingpur area and 53 per cent in the Gadhinglaj area. In the case of direct sale of farmer's produce in the marketing centres, by-passing the village traders,

the share of the producer was 54 per cent in the Jaisingpur area and 57 per cent in the Gadhinglaj area. It is evident, therefore, that in the marketing of tobacco producers get a little more than one half of the second wholesale price. Such a low share of the producer in the tobacco price is due to the high marketing margins maintained by middlemen by various unfair means. (For details see Appendix 5 and 6.)

There are two-fold solutions for increasing the share of the producer in the consumer's price. One is the co-operative marketing and the other is the regulation of markets.

Attempts towards co-operative marketing began in Kolhapur district as early as 1939 when the first co-operative marketing society was established in the Kolhapur market. Later on two more marketing institutions were established and by 1951 each of the three marketing centres in the district had a co-operative marketing institution. The present status of co-operative marketing could be evident from the fact that of the total quantity of *gur* and groundnuts assembled in the markets only 6 per cent and 4 per cent respectively are disposed off through co-operatives. In the case of tobacco the share of the co-operatives was 1·6 per cent in the Jaisinghpur market and 0·7 per cent in the Nipani market. From this it appears that co-operative marketing has not made any spectacular progress in the district. [Appendix 7.]

The data collected by us from 181 cultivators in 8 villages also underline the same fact. Of the 181 cultivators only 7 had sold through co-operatives and the quantity sold by them was only 1·3 of the total quantity sold by all 181 cultivators.

The main reason for the dominance of private agencies in the marketing field is the supply of finance by them. For instance, the total amount of crop finance given to the cultivators by various private agencies in the Kolhapur market during 1953-54 was Rs. 61·5 lakhs. Since there is a positive (Appendix 8) correlation between the advances and arrivals of the produce, dominance of private agencies in marketing is self evident.

The other solution for increasing the share of the producer is the regulation of the markets. With that end in view, the Kolhapur market was regulated in 1945 and Gadhinglaj market in 1948. Such regulation has conferred distinct benefits on the cultivators in the Kolhapur district. The enforcement of auction method of sale has given prices to the cultivators a little higher than those prevailing under the method of sale by ' private negotiation '. More important benefits, however, have arisen from the elimination of malpractices in respect of weighing, refraction allowance (Kadata) and windfall profits. These malpractices, in a more aggravated form, are practically universal in the tobacco trade and therefore, the extension of the Bombay Agricultural Producer Markets Act, 1939, under which markets are regulated, to tobacco would remove many of the abuses which exist at present in the tobacco trade.

Appendix 1

Marketable surplus and village retention of gur *for 80 cultivators*

For farmers with output	Above 1000 lumps	Between 501—1000 lumps	Between 100—500 lumps	As percentage of production	
				Below 100 lumps	Total average for 80 cultivators
Harvest expenses	7·5	6·6	4·8	5·7	6·2
Home retention for consumption	1·0	1·6	3·5	9·3	2·6
Baluta payment	0·6	0·9	2·0	3·6	1·4
Total	9·1	9·1	10·3	18·6	10·2
Marketable surplus	91·9	91·9	89·7	81·4	89·8

Appendix 2

Export of tobacco from Nipani market to various consuming centres (1953)

Consuming centres*	Quantity exported lb.	Per cent to total
Nagpur	68,98,327	32·0
Madras	62,38,890	28·0
Calcutta	34,00,063	15·0
Districts in Bombay Collectorate	34,54,265	16·0
Allahabad	3,64,846	1·5
Patna	12,80,790	6·0
Hyderabad	2,14,579	1·0
Baroda	33,469	0·3
Delhi	16,667	0·2
Total	2,19,01,896	100·0

Source : Excise Department, Nipani Town Circle.
* These names refer to Excise Collectorates and not to cities.

Appendix 3

Share of oligopsonists in the export trade of tobacco in the Nipani Market (1954)

Description	1st biggest above 25 lakhs	Big Between 5 to 25 lakhs	Medium Between 1 to 5 lakhs	Small Below 5 lakhs	Total
	lb.	lb.	lb.	lb.	
Number of traders	1	9	30	68	108
Per cent to tatal traders	0·9 per cent	8 per cent	28 per cent	63·1 per cent	100 per cent
Quantity bought	51,03,568	87,94,717	72,15,370	20,88,141	2,32,01,796
Per cent to total quantity	22 per cent	38 per cent	31 per cent	9 per cent	100 per cent

Source : Computed from the data obtained from the Records of the Excise Department, Nipani.

Appendix 4

Farmer's share in the second wholesale price of gur *(Kolhapur Market)*

Year	Total commission	Other costs	Total marketing costs	Farmer's share
	Per cent	Per cent	Per cent	Per cent
1948-49	3·1	1·3	4·4	95·6
1949-50	3·1	1·0	4·1	95·9
1950-51	3·1	1·4	4·5	95·5
1951-52	3·1	2·5	5·6	94·4
1952-53	3·1	2·3	5·4	94·6
1953-54	3·1	1·7	4·8	95·2
1954-55	3·1	2·3	5·4	94·6

Note :—Marketing cost refers to all costs incurred until *gur* is put in railway wagon and/or truck as the case may be, but does not include transport charges.

Appendix 5

Summary of the marketing cost of tobacco during various stages of its movement from the producer to the bidi *manufacturer*

(As a percentage of the second wholesale price)

Agency	Jaisingpur area	Gadhinglaj area
	Per cent	Per cent
Village trader's net margin	30	20
Net cost of second stage of marketing	8	5
Wholesale trader's net margin	20	20
Incidental costs	2	2
Total cost of marketing	60	47
Share of tobacco grower in the second wholesale price	40	53

Appendix 6

Excess quantity of tobacco deducted in kind during village sales in Jaisingpur and Gadhinglaj area

(Per maund of 20 seers)

Name of deduction	Jaisingpur area (in seers)	Per cent to total	Gadhinglaj area (in seers)	Per cent to total
		Per cent		Per cent
(i) *In kind*—				
1. Tare ('Bardan Soot')	0·7	3·5	0·7	3·5
2. Balance ('Kanta Soot')	0·3	1·5	0·3	1·5
3. Refraction ('Vajan Soot')	4·0	20·0	2·0	10·0
4. Stalks ('Kadi Soot')	2·0	10·0	2·0	10·0
Total	7·0	35·0	5·0	25·0

Appendix 7

Volume of gur *and groundnut handled by Co-operative Marketing Societies in Kolhapur and Gadhinglaj Markets*

(Percentage of the total)

Market	Commodity	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54
Kolhapur	*gur*	1·53	2·16	2·56	7·84	6·04	5·60
	Groundnut	3·31	3·00	0·74	3·05	3·60	3·50
Gadhinglaj	*gur*	..	..	9·55	15·77	12·75	9·32
	Groundnut	..	..	11·76	13·70	6·60	8·00

Source : Compiled from the data obtained from the Annual Reports of the Co-operative Marketing Societies.

Appendix 8

Functional relation between advances given to farmers and share in volume of business in Kolhapur Market 1953-54

(121 Commission Agents)

Size groups of commission agents	Commission agents in the group to the total	Share in advances	Share in *gur*	Share in groundnut
	Per cent	Per cent	Per cent	Per cent
1. Big	14	73	64	40
2. Medium	24	13	15	15
3. Small	44	12	16	26
4. Very small	18	2	5	19
Total	100	100	100	100

Source : Compiled from the data obtained from the records of the Agricultural Produce Market Committee, Kolhapur and the Office of the Registrar of Moneylenders, Kolhapur.

REVIEWS

ELEMENTARY SOIL AND WATER ENGINEERING

By Glenn O. Schwab, Richard K. Frevart, Kenneth K. Barnes and Talcott W. Edminster

Published by John Wiley & Sons, New York, Chapman & Hall Ltd., London (1957), pp. 296.

PROPER soil and water management to ensure the most effective use of each has an important bearing on improvement in land utilisation more particularly for countries like India, which have peculiar rainfall and climatic conditions. This subject has been developed recently and there are very few elementary text books, that take an engineering approach to this problem in a lucid manner. This book is a condensed version of the bigger book written by the same authors and gives in a nutshell the vast subject of Conservation Engineering, including agronomic aspects of erosion control, land clearing, irrigation and drainage. In addition to the engineering phases of soil and water conservation it considers agronomic, economic and other aspects of these problems.

Earlier chapters dealing with measurement of distances, surveying and levelling and mapping will be of great help to students and beginners including those who have little or no engineering background. They also help to arrive at a proper understanding of the problems arising out of rainfall and wind and general characterisation of erosion types.

The remaining chapters are of great utility in the planning and execution of conservation work, including vegetative and mechanical control measures, conservation of moisture, cropping and cultural practices, design and construction of mechanical structures like terraces, water courses and outlets, gully control and structures like drop spillway, chutes, etc., used therein, wind-erosion control, surface and sub-surface drainage of water-logged area through construction of open ditches and tile drains including principles of design for proper outlets, etc., land-clearing for reclamation, farm-ponds for flood control works and sprinkler irrigation. A separate chapter on "Soil Conservation Farming" covering farm and watershed planning, their economic aspects, collection of data, and soil and water management programme, including classification of land uses according to its capability, add considerably to the value of this book. The only lacuna one notices in this book is the absence of a chapter on "Conservation Irrigation" which is very important for economic and efficient utilisation of water resources in profitable crop production without at the same time causing soil erosion, depletion and wasteful water use.

This book will be a useful guide to soil conservation research workers in planning programmes according to the need of the tract and in the execution of various erosion control and other structures. The laboratory problems furnished in Appendix A and definitions of various nomenclatures in Appendix B will be of immense use to students and lecturers. A proper understanding and application of the appropriate methods of soil and water management is imperative to ensure the most effective use of these measures to conserve soil and water for successful crop production on a sustained basis. This book, therefore, can be confidently recommended as a text book in all agricultural schools and colleges.

GOSSYPIUM LINN.

(Reprinted from *Wealth of India—Dictionary of India Raw Materials and Industrial Products*, published by the Council of Scientific and Industrial Research, New Delhi.)

Issued by Indian Central Cotton Committee, Bombay, pp. 226, Price Rs. 10,

THIS monograph was originally compiled in connection with the revision of Dr. George Watt's "Dictionary of Economic Products of India". The compilation of information relating to cotton was assigned by the Council of Scientific and Industrial Research to the Indian Central Cotton Committee and the preparation of material relating to the various aspects of the commodity, viz. botany, cultivation, marketing and technology was entrusted by the latter organisation to eminent authorities.

The monograph begins with a descriptive review of the various species of *Gossypium* and deals extensively with cotton cultivation including such topics as climate, soil, cultural operations, diseases, pests, harvest and yield. There is a section on cotton improvement in which selection, hybridization and acclimatisation; an an account is given of the characteristic features of cotton crops in different cotton-growing areas of the country. The section dealing with marketing, production and trade includes, all important information relating to this aspect of the commodity. Cotton fibre and cotton technology have received adequate treatment, as also the cottonseed and the products derived from it.

The monograph is well produced and it contains a large number of illustration and several coloured plates. It should be of interest to all interested in cotton.

GRASSLAND SEEDS

By W. A. Wheeler and D. D. Hill

Published by D. Van Nostrond Co. Inco., Princeton (1957), pp. XX+743, Price Rs. 12·50.

THIS volume contains useful information about grass and legume seeds which are used for grassland sowing and soil conservation planting ; the seeds dealt with are those that are generally used for these purposes in the United States. The book brings all the important and scattered information about such seeds into one compact volume and is specially welcome as a demand for such a comprehensive compilation of information relating to grasses and legume seeds has been felt for a long time.

The book is divided into three parts. The first part deals with general information relating to grassland seeds and with such subjects as seed formation and germination, testing of field seeds, insect pollination of legumes, insects injurious to forage seeds, treatment of forage seeds for disease control, legume seed inoculation, harvesting and threshing of forage seeds; there are also chapters on storing, marketing and trade. The second part deals with specific grasses and legumes and the problems connected with their seed production. The third part, which serves as an appendix, is devoted to the definition of technical terms, field seed statistics, seed certification standards, etc. In addition to the contribution of the authors, the book, which has been sponsored by the Field Seed Institute of North America and the American Seed Trade Association, contains a number of chapters written by specialists in their respective fields.

The book is an authoritative compilation of information on grassland and legume seeds. Although specially meant for the seed producers and relevant commercial interests in the United States, the publication will be found useful in other countries, as well, where such seed production is undertaken. It will undoubtedly be of great help to all those who are interested in the subject, either students or research workers, and specially so to seed growers and technical and commercial organisations dealing with grassland and legume seeds. It is well printed, copiously illustrated and securely bound.

THE GRASSLAND AND FODDER RESOURCES OF INDIA

By R. O. Whyte

Published by Indian Council of Agricultural Research, New Delhi, (1957), pp. 437, Price Rs. 16

A COMPREHENSIVE statement of grassland and fodder resources of India was long overdue. It is gratifying to find that such a publication has at last been brought out. The present book is the outcome of a special study carried out by an expert of the F.A.O., Dr. R. O. Whyte, who was especially commissioned for this purpose. This is probably the first time that such a comprehensive compilation of information relating to grassland and fodder resources of India has been published. The book contains 17 chapters ; in addition, there are references, index of subjects, glossary of Indian terms, and indices of genera and species and geographical names. The whole range of grassland and fodder resources have been surveyed *vis-a-vis* the livestock problem of the country. There are chapters in which discussions on ecological studies of grassland, and grassland types have been undertaken. The problem of forage grassland has also been examined at length as also the problem of nomadic and migratory grazing. There are special chapters devoted to grazing in forests, soils and fertilisers, and breeding and seed supplies. Such subjects as mixed farming and agrarian structure have also been dealt with. It is a voluminous publication with 437 pages of text and 50 plates ; a special feature is a large number of tabular statements containing useful data and information. The publication is a genuine contribution to the literature on the subject and is surely to be looked upon as a handy reference book for teachers, research workers, foresters and all those who are interested in grasses and fodder in India. The graduate students can also get much helpful information for their course work from this book. It is well printed and handsomely produced. Considering the volume of the book, the quality of its get-up and its general usefulness, its sale price must be considered to be moderate.

MGIPC—M—81 AR/58—6-5-59—2,300.

INDIAN TEXTILE INDUSTRY

(Cotton, Woollen & Rayon)

STATISTICAL BULLETIN.

————:0:————

A Monthly : : Issued by :

THE OFFICE OF THE TEXTILE COMMISSIONER
MINISTRY OF COMMERCE & INDUSTRY
GOVERNMENT OF INDIA
BALLARD ESTATE, BOMBAY-1.

* * * * *

INDISPENSABLE TO MANUFACTURERS OF TEXTILE GOODS, TEXTILE MACHINERY AND DISTRIBUTORS.

————:0:————

REGULAR CONTENTS.

Graphical Illustrations showing Production & Consumption of Cotton Yarn and Cloth and Labour employed, etc.
Gives All Kinds of Statistical Data Relating to :
Production of Cotton, Cotton Waste, Woollen, Rayon and Staple Fibre : Yarn and Fabrics.
Consumption of Indigenous & Imported Cotton. Import and Export of Cloth.
Packings and Deliveries of Cloth and Yarn.
Spindles and Looms Installed in Textile Mills (Both Cotton and Woollen).
Production of Important Items of Cotton Textile Machinery in the Country.
Labour Employed in and Shifts worked by Cotton Textile Mills, Deliveries of Cotton Waste, Cloth and Yarn for Home Consumption & Exports
Latest and Uptodate figures given each month, etc., etc.

* * * * *

Price : Rs. 1-8-0 or 2sh. 3d. per copy.

Annual subscription Rs. 18-0-0

Available From :

Mail Orders

MANAGER OF PUBLICATIONS
Civil Lines, DELHI-8.

Cash Sale only

Government of India Kitab Mahal, Queensway Barracks, NEW DELHI.
Government of India Book Depot, 8, Hastings Street, CALCUTTA

AND

All Reputed Agents for sale of Government Publications.

NOTE : Prices are inclusive of packing and postage charges in India. Cost should be remitted with the order. Treasury Challans will not be accepted from non-Government indentors as payment for publications ordered.